TRAINING MATERIALS

The Application of Advanced Geophysical Classification in Support of Munitions Response Program- An Outreach to Federal, State and Local Regulators and Tribal Governments

ESTCP Project MR-201590-T2

Mr. Jim Austreng
Department of Navy, NAVFAC-EXWC

Mr. Bryan Harre
Naval Facilities Engineering Service Center

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ESTCP

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

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1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
04-18-2017	Training Materials	09/2015 – 04/2017

4. TITLE AND SUBTITLE

The Application of Advanced Geophysical Classification in Support of Munitions Response Program- An outreach to Federal, State and Local Regulators and Tribal Governments

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

Mr. Jim Austreng

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

NAVFAC
1000 23rd Avenue
Port Hueneme, CA 93043

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Environmental Security Technology Certification Program
4800 Mark Center Drive, Suite 17D03
Alexandria, VA 22350

10. SPONSOR/MONITOR'S ACRONYM(S)
ESTCP

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
MR-201590

12. DISTRIBUTION / AVAILABILITY STATEMENT

Unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

The course was designed to teach California's regulators about the AGC technology, the benefits of the technology, and implementation issues. Course topics included: a history of the Military Munitions Response Program; the development and testing of the AGC technology; an explanation of how the technology works; what are the quality assurance and quality control requirements of the AGC technology; contractor accreditation; and several class exercises. AGC has already been used on some munitions response sites in California, and it is expected to be proposed for use on more projects in the state, particularly for the investigation phase and the remedial action phase.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			Jim Austreng
U	U	U	UU	481	**19b. TELEPHONE NUMBER** *(include area code)* 805-982-1660

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

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The Application of Advanced Geophysical Classification in Support of the Munitions Response Program:

An Outreach to Federal, State, Local Regulators
and
Tribal Governments

November 1-2, 2016
California's Department of Toxic Substances Control
Cypress, CA







AGENDA
Day 1

0830-0900	Welcome & Introduction plus Ice Breaker	John Scandura & Roman Racca
0900-0950	Purpose- How Did We Get Here…A 30 year Journey	Jim Austreng & Doug Maddox
0950-0955	Mini-break	
0955-1035	DoD $14B Liability, DERP Goals and Problem with Status Quo	Andy Schwartz
1035-1045	Break	
1045-1115	ESTCP- Demonstration Program	Bryan Harre
1115-1215	Lunch	
1215-1445	The Physics- and 3-D modeling & breaks as needed	John Jackson
1445-1545	Commercial Application- VSP & Vertical CSM	John Jackson & Andy Schwartz
1545-1600	Intro To QAPP	Doug Maddox
1600-1630	Open discussion/Day's Wrap up	All

AGENDA
Day 2

0830-0845	Day Two Q&A	All
0845-1030	QAPP & breaks as needed	John Jackson
1030-1115	QAPP Exercise	John Jackson
1115-1215	Lunch	
1215-1300	Accreditation, Regulatory Perspectives and 3rd Party QA	Andy Schwartz & Doug Maddox
1300-1415	Risk Management	Andy Schwartz
1415-1425	Break	
1425-1445	VSP Exercise	All
1445-1530	Post Remedy Analysis Exercise	All
1530-1600	Summary	Jim/Doug/John/Andy
1600-1800	Final Exam	All

Advanced Geophysical Classification

How we got Here - A 30 year journey

Jim Austreng, P.E.
NAVFAC Engineering and Expeditionary Warfare Center (EXWC)
Environmental Restoration Technology Development (EV31)
1000 23rd Ave
Port Hueneme, CA 93043
(805) 982-1660

Framework

- Interactive, i.e., avoid DBPP (Death By Power Point)
- History of AGC Development
- Understand the physics supporting AGC (does not mean we expect you to be a geophysicist)
- Systematic Planning and UFP-QAPP
- Limitations of AGC
- Quality - The new Paradigm

Key Terminology for AGC

- Detection Survey or Dynamic Survey: find where metal exists underground
- Cued Survey: Sitting on top of anomaly to collect high SNR AGC data
- Single-Axis Sensor: "Traditional" metal detector
- Multi-Axis Sensor: "New-Tech" used for classification
- Electromagnetic Induction (EMI): the fundamental basis of the technology
- Anomaly: Metallic item that causes a geophysical response
- Informed Source Selection: Smart anomaly picking
- Clutter: Non-hazardous metal "FRAGments" or other debris
- Targets of Interest (TOI): potentially hazardous anomaly or any other item of interest
- Classify: Determine whether "TOI" or "Non-TOI"
- Validate: Prove your "classification" worked as expected
- QC & Validation Seeds: Key components used to "validate" the AGC process

Historical Events

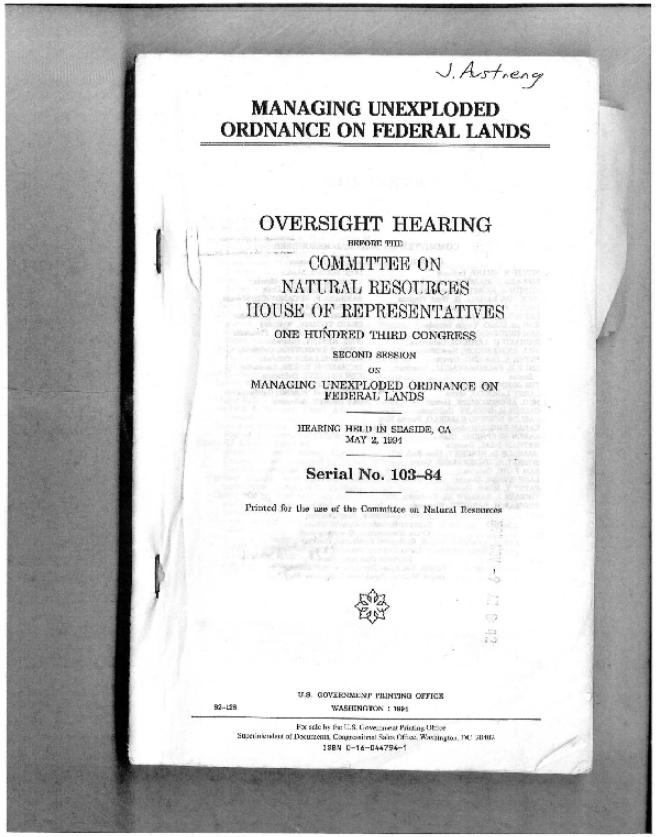
- 1983 Tierrasanta Accident- not the only one, just very influential
- 1986 Superfund Amendments and Reauthorization Act/DERP
- 1988 Base Realignment And Closure Act (1st Round)
- 1990s Proposed Range Rule and Range Rule Risk Methodology
- 1991 Develop On Site Technology (DOIT) Committee
- 1999 Interstate Technology and Regulatory Council (ITRC) UXO Workgroup
- 2000 EPA & DOD UXO Management Principles

Search for Technical Solutions

- 1991 Develop On-site Innovative Technologies (DOIT Committee)
- 1994 U.S. House of Representatives Subcommittee Hearing
- 1999 Inaugural Session of ITRC UXO Work Group
- 2000 Fort Ord ODDS Study

U.S. House of Representatives Subcommittee Hearing

- Members: DoD, DOI, DOE, EPA and Western Governors' Association
- DOIT UXO Sub-Committee 1994
  - Push for Innovative Technologies, e.g., 3-dimensional imaging



J. Astreng

MANAGING UNEXPLODED ORDNANCE ON FEDERAL LANDS

OVERSIGHT HEARING

BEFORE THE

COMMITTEE ON NATURAL RESOURCES HOUSE OF REPRESENTATIVES

ONE HUNDRED THIRD CONGRESS

SECOND SESSION

ON

MANAGING UNEXPLODED ORDNANCE ON FEDERAL LANDS

HEARING HELD IN SEASIDE, CA MAY 2, 1994

Serial No. 103–84

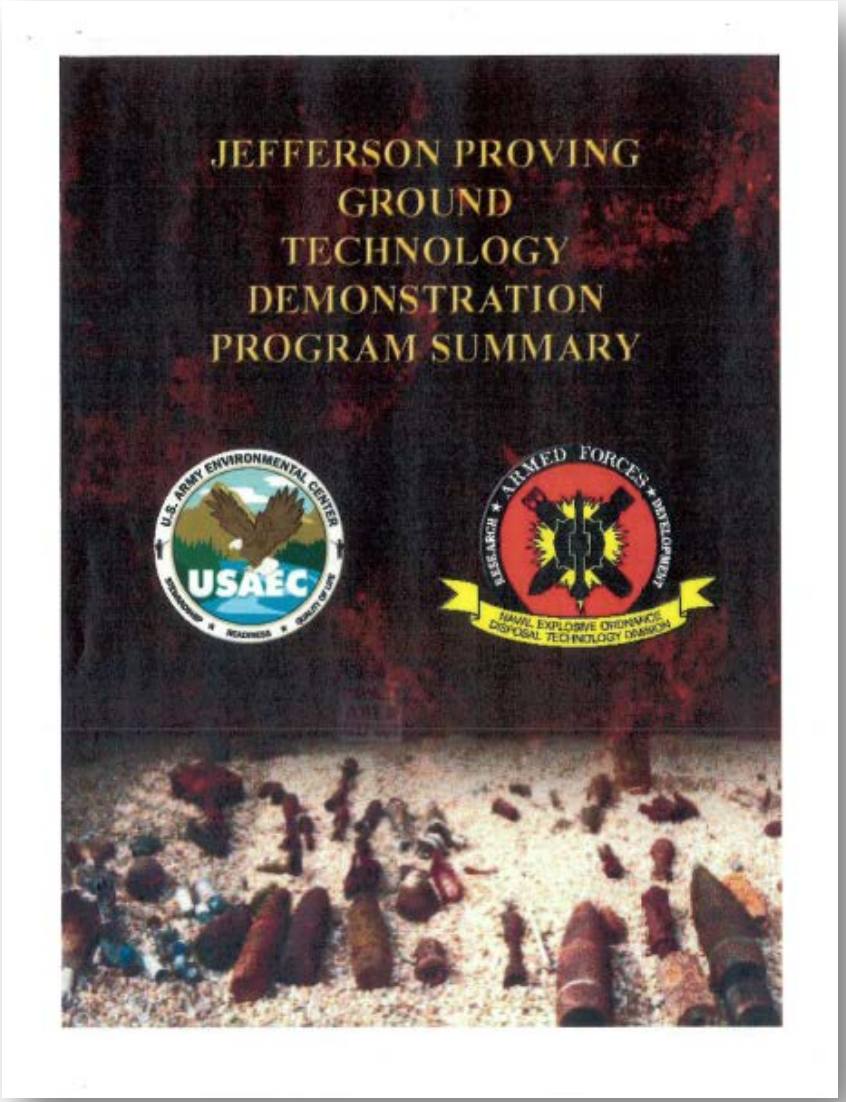
Printed for the use of the Committee on Natural Resources

U.S. GOVERNMENT PRINTING OFFICE

WASHINGTON : 1994

Progress

- 1994-1999
  - Jefferson Proving Ground Technology Demonstration Program, Phase I – IV



Eye Opener

- JPG

  Examined state of the art geophysical platforms and their capability to "…detect, classify and remove Unexploded Ordnance (UXO)."

- Phase I included Congressional mandate to test most applicable technologies at five "Live Sites"
  - Results: "The Average P_D [probability of Detection]…was 0.44."

JPG (Continued)

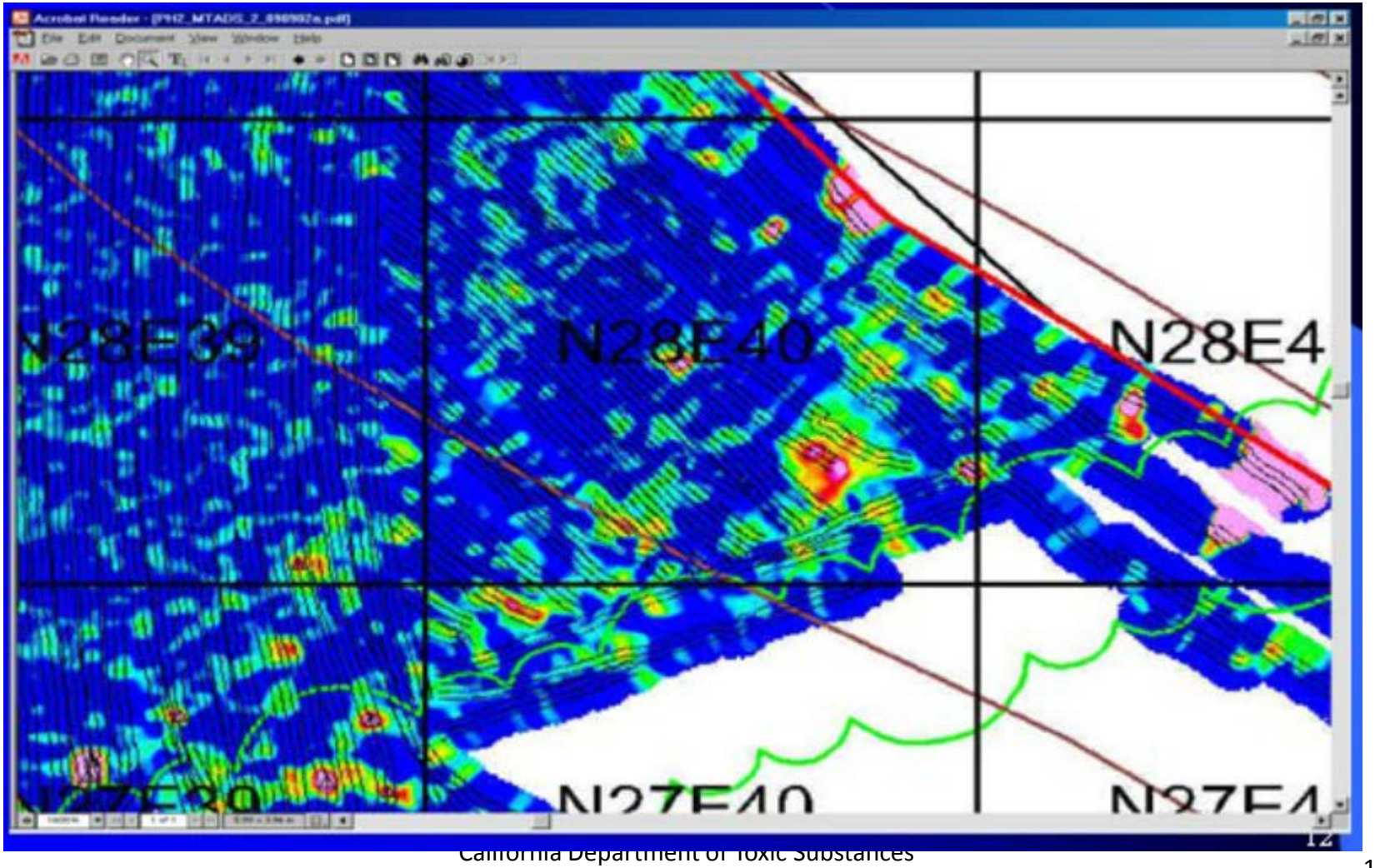
- P_D Improved through Phase II-III but tradeoff was increase number of false positives

- Phase IV (1996) focused on demonstrating discrimination capabilities
  - Early days of what is now Advanced Geophysical Classification

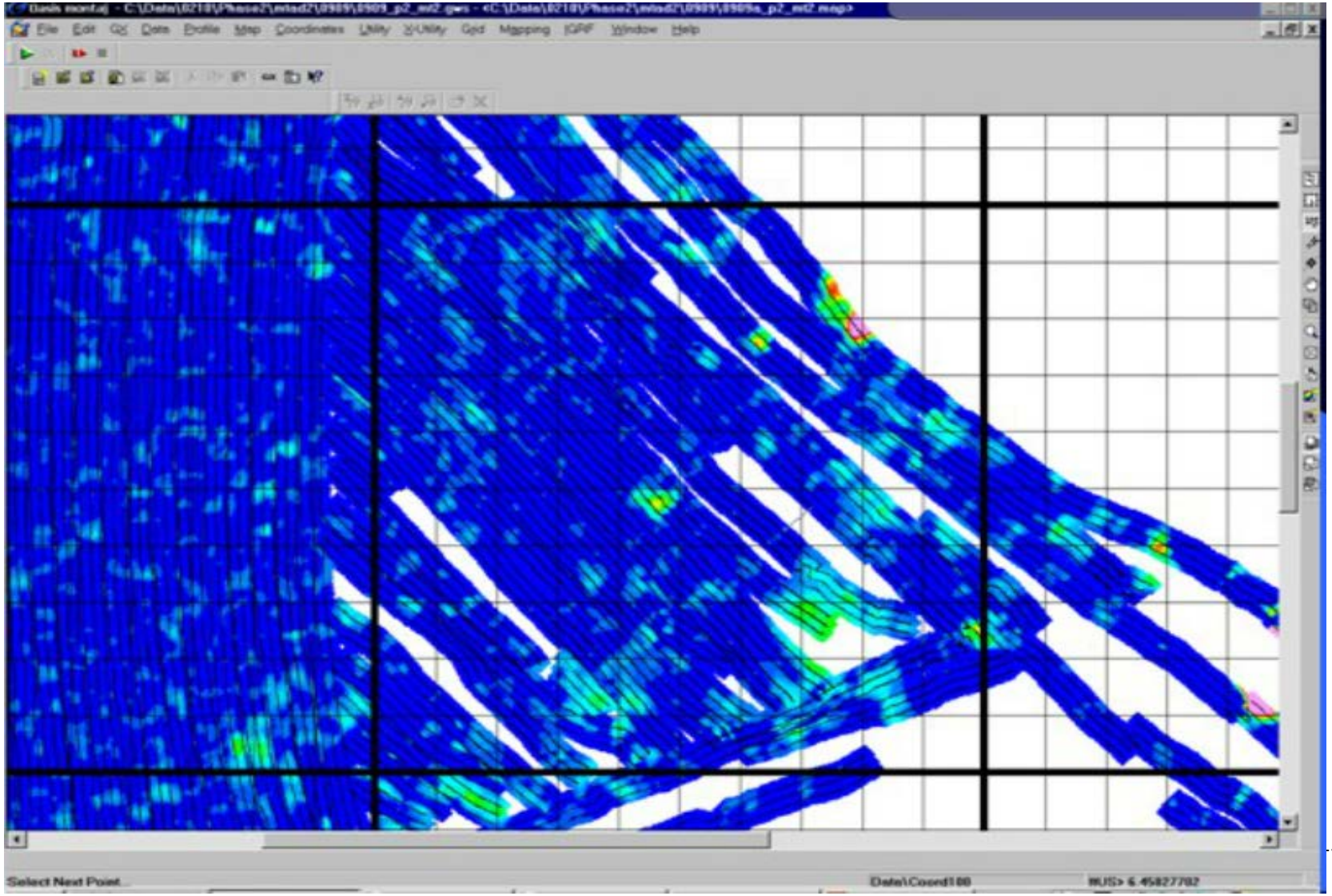
Analog



The Answer?

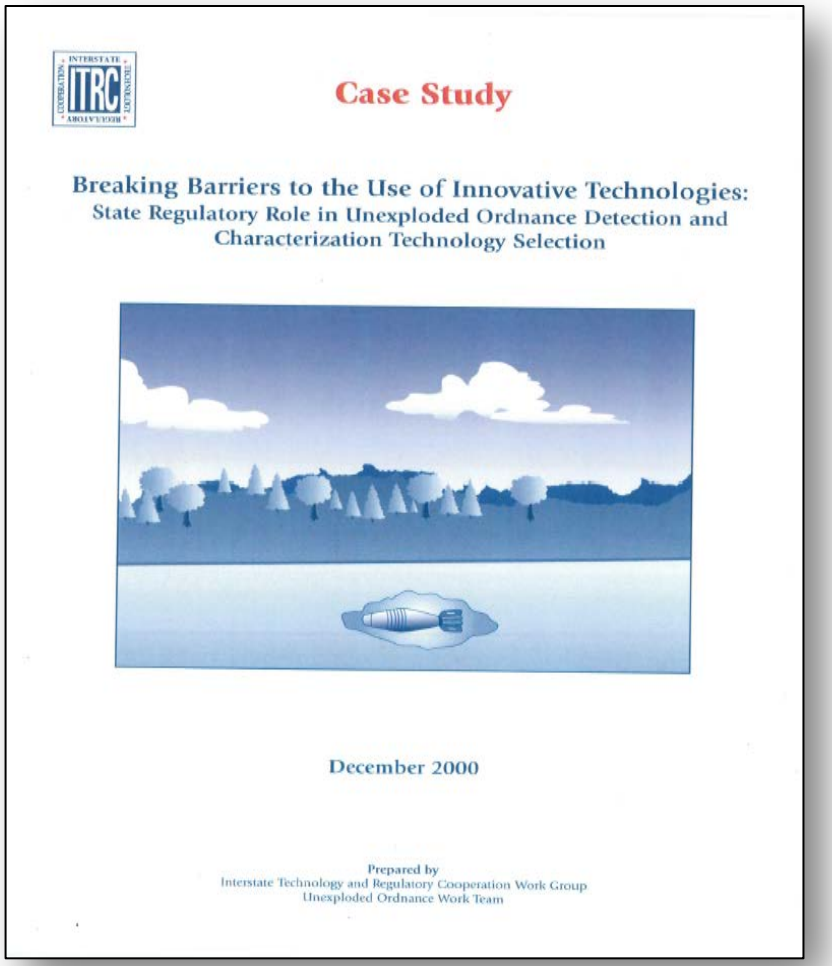


Correctly Processed



1999 ITRC UXO Workgroup

- First UXO Report: December 2000 with emphasis of demonstrating digital technologies and pursuing those with discrimination capabilities.



Defense Science Board

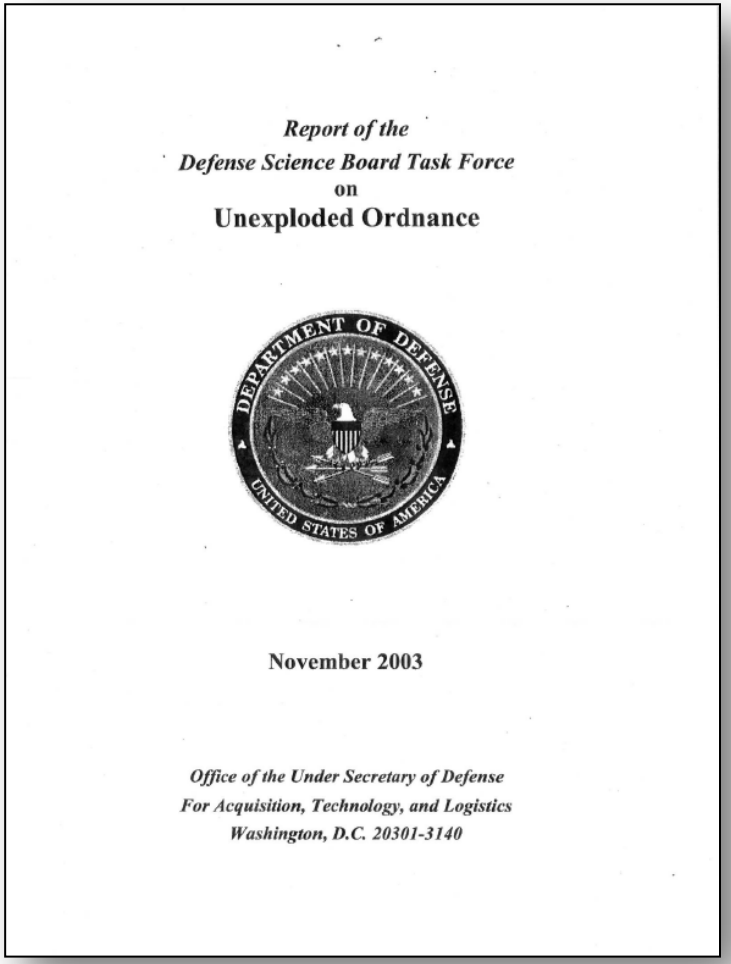
Transmittal Memorandum,
William Schneider, Jr.,

October 24, 2003

> **"The Task Force found that technology can be of dramatic help in each problem area. The current cleanup problem is massive in scale but there is a clear opportunity to save tens of billions of dollars in the total cleanup process by the use of more modern technology"**

Appendix J, page 2

> **"We then "process the daylights" out of this data with powerful digitally implemented algorithms and data processing routines"**



Report of the
Defense Science Board Task Force
on
Unexploded Ordnance

November 2003

Office of the Under Secretary of Defense
For Acquisition, Technology, and Logistics
Washington, D.C. 20301-3140

Survey of Munitions Response Technologies







Prepared by:

The Environmental Security Technology Certification Program (ESTCP)
The Interstate Technology & Regulatory Council (ITRC)
The Strategic Environmental Research and Development Program (SERDP)

June 2006

The publication of this document does not indicate endorsement by the Department of Defense, nor should the contents be construed as reflecting the official position of that Agency. Mention of specific product names or vendors does not constitute an endorsement by any of the authoring organizations.

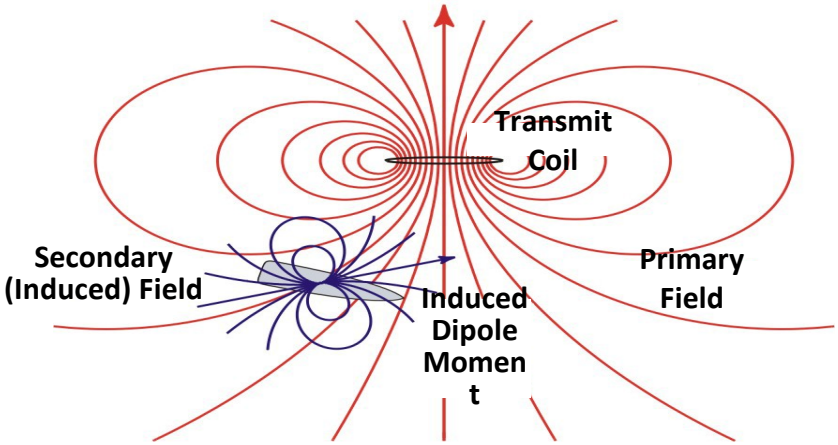
Sensors of Choice



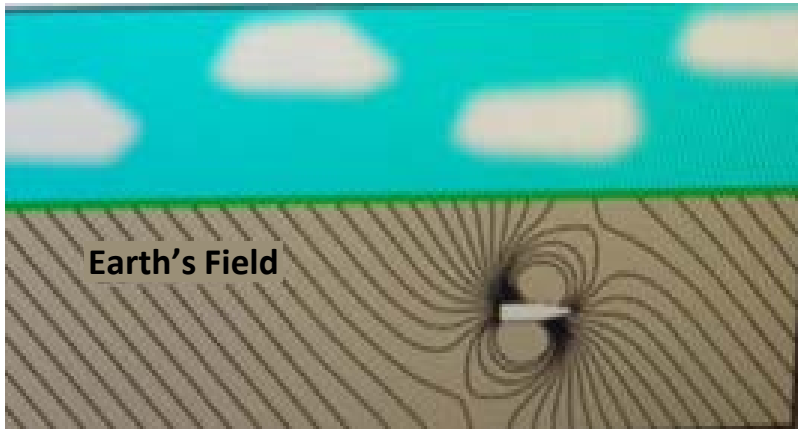
Wheeled EMI System
Photo courtesy of US Army



Geometrics G-858 Portable Cesium Magnetometer/Gradiometer
Photo courtesy of Geometrics



Typical Electromagnetic Induction Sensor



We Learned

- Dipole Modeling
- Detection Curves
- Geophysical Prove Outs

But Wait!!!

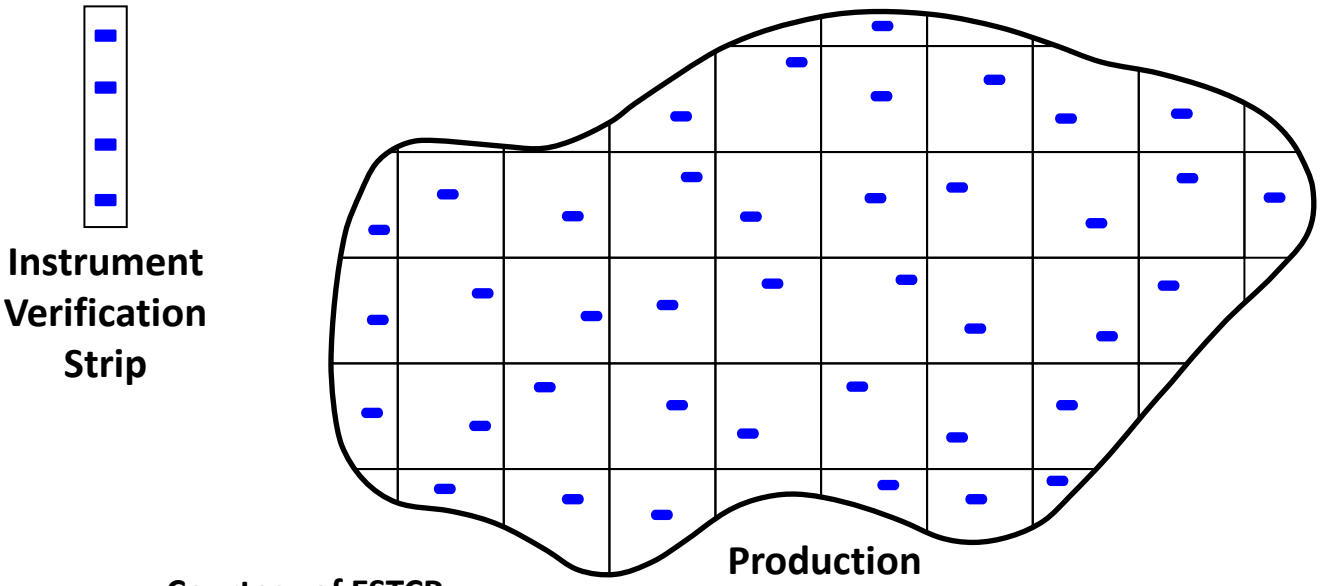


Need Geophysical Prove-Outs?

- Does not translate (or indicate) quality of field work
- Has significant statistical uncertainties
- GPO construction is not representative of site conditions
- Excess construction costs, needless document production requires two mob/de-mobs

Principal of GSV Process

- Provides documentation through the use of a physics-based approach that is transparent, objective, and provides quantifiable results allowing unbiased validation that the project data quality objectives (DQOs) and hence, the response action objectives have been met



Courtesy of ESTCP
https://www.serdp-estcp.org/

Paradigm Shift

- Classification- requires High Fidelity Data
- Quality from Start to finish
- Accreditation
- Not just for Classification-Quality from Start to finish

MR Response Process

Site Preparation

Vegetation and Surface Clearance, IVS, Seeding

↓

Geophysical Data Collection

Dynamic Detection Survey, Cued Data as Needed

↓

Analysis

Parameter Extraction, Classification, Initial Ranked Dig List

↓

Digging

Training and Confirmation Digs until Final Ranked Anomaly List

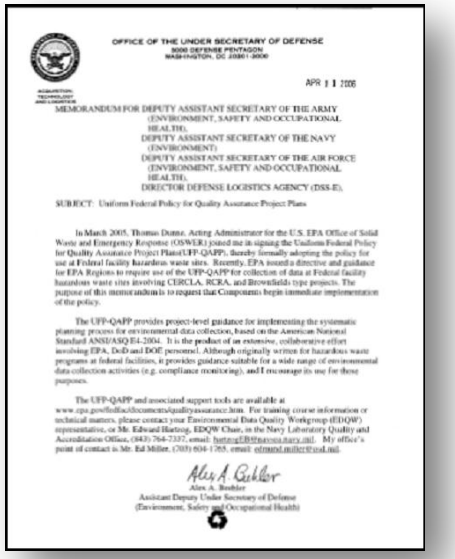
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Scoring

Evaluate Blind Seeds, Recovered TOI, Clutter Rejection

Uniform Federal Policy for Quality Assurance Project Plans

- Jointly developed by EPA, DoD, DOE
- Sets requirements for all environmental data collection, including MR data
- Provides details for
  - Specific data requirements or other information that must be collected to demonstrate conformance to requirements
  - Required data in 37 worksheets
  - Emphasis on systematic planning



OFFICE OF THE UNDER SECRETARY OF DEFENSE
3000 DEFENSE PENTAGON
WASHINGTON, DC 20301-3000

APR 1 1 2006

MEMORANDUM FOR DEPUTY ASSISTANT SECRETARY OF THE ARMY (ENVIRONMENT, SAFETY AND OCCUPATIONAL HEALTH),
DEPUTY ASSISTANT SECRETARY OF THE NAVY (ENVIRONMENT)
DEPUTY ASSISTANT SECRETARY OF THE AIR FORCE (ENVIRONMENT, SAFETY AND OCCUPATIONAL HEALTH),
DIRECTOR DEFENSE LOGISTICS AGENCY (DSS-E),

SUBJECT: Uniform Federal Policy for Quality Assurance Project Plans

In March 2005, Thomas Dunne, Acting Administrator for the U.S. EPA Office of Solid Waste and Emergency Response (OSWER) joined me in signing the Uniform Federal Policy for Quality Assurance Project Plans(UFP-QAPP), thereby formally adopting the policy for use at Federal facility hazardous waste sites. Recently, EPA issued a directive and guidance for EPA Regions to require use of the UFP-QAPP for collection of data at Federal facility hazardous waste sites involving CERCLA, RCRA, and Brownfields type projects. The purpose of this memorandum is to request that Components begin immediate implementation of the policy.

The UFP-QAPP provides project-level guidance for implementing the systematic planning process for environmental data collection, based on the American National Standard ANSI/ASQ E4-2004. It is the product of an extensive, collaborative effort involving EPA, DoD and DOE personnel. Although originally written for hazardous waste programs at federal facilities, it provides guidance suitable for a wide range of environmental data collection activities (e.g. compliance monitoring), and I encourage its use for these purposes.

The UFP-QAPP and associated support tools are available at www.epa.gov/fedfac/documents/quality assurance.htm. For training course information or technical matters, please contact your Environmental Data Quality Workgroup (EDQW) representative, or Mr. Edward Hartog, EDQW Chair, in the Navy Laboratory Quality and Accreditation Office, (843) 764-7337, email: hartogEB@navsea.navy.mil. My office's point of contact is Mr. Ed Miller, (703) 604-1765, email: edmund.miller@osd.mil.

Alex A. Beehler
Alex A. Beehler
Assistant Deputy Under Secretary of Defense (Environment, Safety and Occupational Health)

QAPP Worksheet for Classification

Worksheet #		Title	
1 & 2	Title and Approval Page	20	Quality Control and Corrective Action
3 & 5	Project Organization and QAPP Distribution	21	Field and Data Analysis SOPs
4, 7, & 8	Personnel Qualifications and Sign-off Sheets	22	Field Equipment Calibration, Maintenance, Testing and Inspection
6	Communication Pathways	29	Project Documents and Records
9	Project Planning Session Summary	31	Planned Project Assessment
10	Conceptual Site Model	32	Change Control Document
11	Data Quality Objectives	33	QC Management Reports
12	Measurement Performance Criteria	37	Data Usability Assessment
13	Secondary Data Uses and Limitations	34	SAP Verification
14 &16	Project Tasks and Schedule	35	SAP Validation
17	Sampling Design and Project Work Flow	36	Product QC Tier 3 Summary Report

Worksheet Not Used for Geophysical Classification

Worksheet #	Title
15	Project Action Limits and Evaluation
19	Analytical Methods/SOP Requirements
20	Field Quality Control Sample Summary
23	Analytical SOP References
24	Analytical Instrument Calibration
25	Analytical Instrument & Equipment Maintenance, Testing and Inspection
26	Sample Handling System
27	Sample Custody Requirements
28	Laboratory QC Samples Table
30	Analytical Services Table

QAPP – SOPs

1	Assemble the Geophysical Platform (MetalMapper, etc.,) and verify correct operation
2	Test Sensor and System at the IVS
3	Production Area Seeding
4	Collect Dynamic Data Using the advanced geophysical platform
5	Preprocess Dynamic Data and Identify Anomalies
6	Collect Static Background Measurements
7	Collect Cued Target Measurements
8	Verify Usability of Advanced Sensor Data
9	Background Correct Cued Anomaly Data
10	Invert anomaly data to extract source parameters
11	Compare extracted parameters to MEC signatures in the data library
12	Develop prioritized dig list using library matching and other factors
13	Verify recovered objects are compatible with predictions based on the advanced sensor data
14	Develop verification sampling dig list and perform verification sampling

Quality Throughout the Process

- Avoid Garbage in, Garbage out



Knowledge Test #1



Classification – a Paradigm Shift for Munitions Response

Naval Facilities Engineering Command
ENGINEERING AND EXPEDITIONARY WARFARE CENTER

Questions?

Naval Facilities Engineering Command
ENGINEERING AND EXPEDITIONARY WARFARE CENTER

Back Up Slides



Courtesy of Les Clarke, Battelle

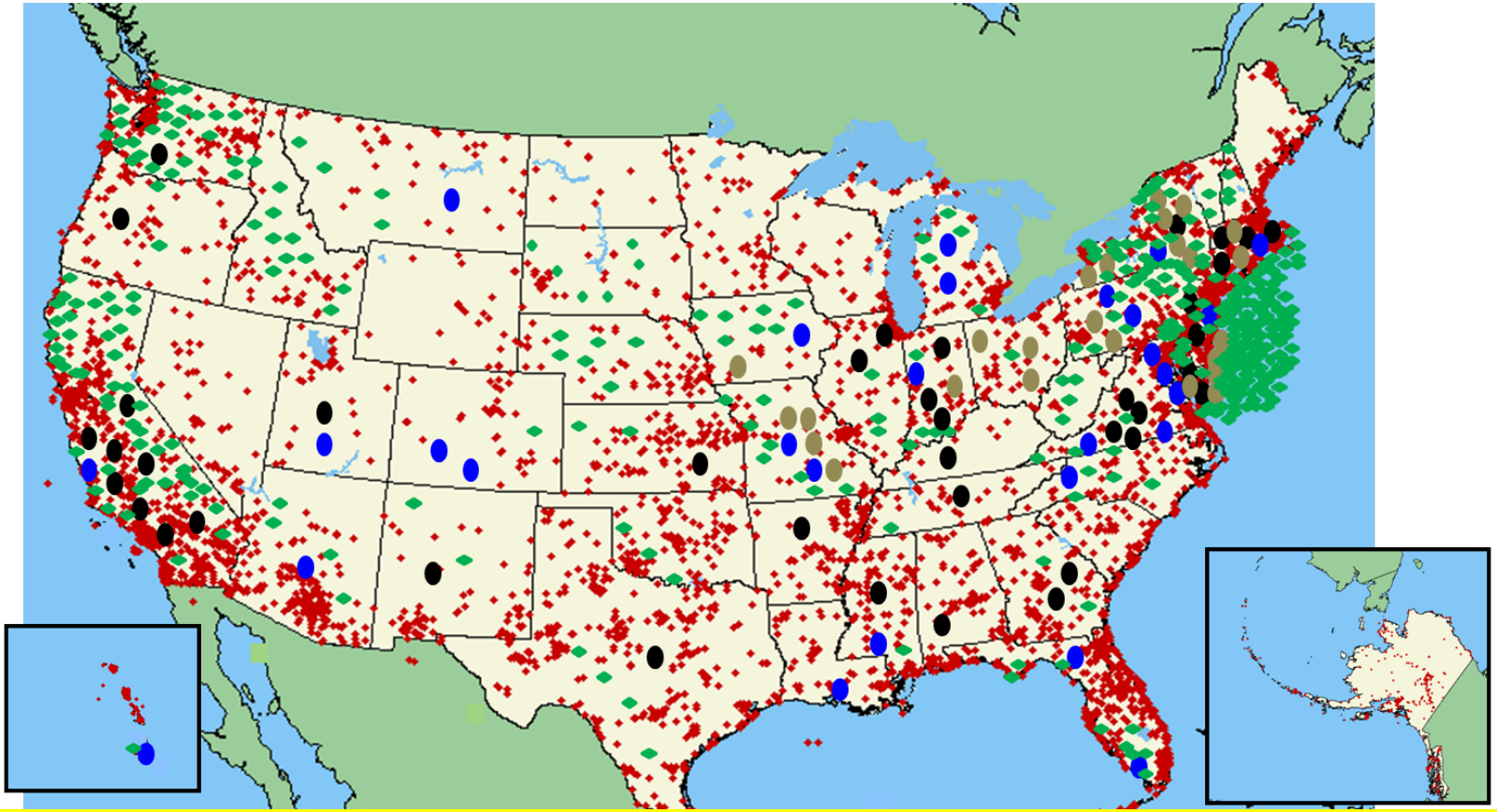
MILITARY MUNITIONS RESPONSE PROGRAM (MMRP)

Advanced Geophysical Classification (AGC)

US Army Corps of Engineers

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USACE NATIONWIDE CLEAN-UP PROGRAM



- FUDS (Formerly Used Defense Sites) – Mostly **WWI, WWII,** and later military sites
- FUSRAP (Formerly Utilized Sites Remedial Action Program) – Low-level radioactive, non-DOD sites, including DOE **Atomic Energy Era** projects
- BRAC – Current Projects
- BRAC – Closed Projects
- SUPERFUND (National Priorities List) – Former **Industrial** sites with hazardous waste; USACE work for EPA

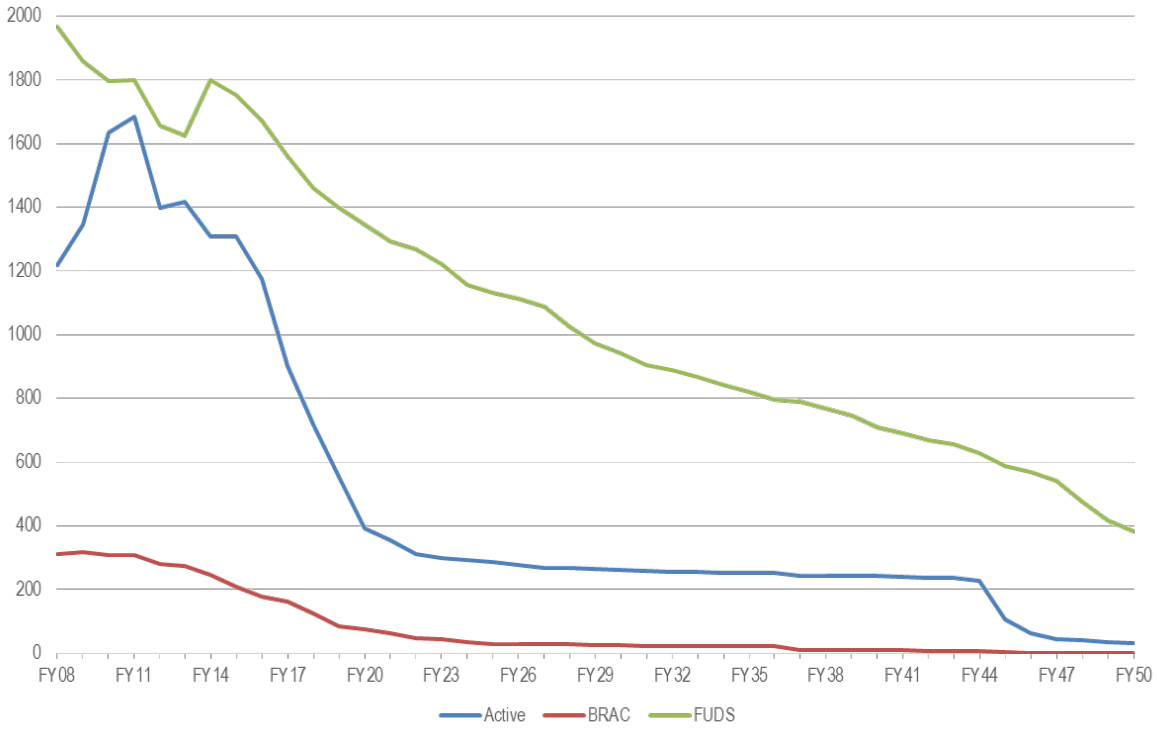
***Does not include USACE clean up work at Army, AF, NGB, and Reserve Installations**

US Army Corps of Engineers

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THE REALLY BIG PICTURE

DERP Fiscal Year 13 Annual Report To Congress: MMRP CTC ~$13B
Fiscal Year 17 ER(IRP & MMRP) Budget Request: $1.3B
Fiscal Year 17 MMRP Budget Request: $221.1M
($13B/$221.1M/year=59 years)



Total Number Of DERP Projects

- Army
- BRAC
- FUDS

US Army Corps of Engineers

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THE REALLY BIG PICTURE – AT THE TOP

DoD Instruction (DoDI) 4715.07, *Defense Environmental Restoration Program (DERP)*, May 21, 2013

DoD Manual (DoDM) 4715.20, *Defense Environmental Restoration Program (DERP) Management*, March 9, 2012

US Army Corps of Engineers

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THE REALLY BIG PICTURE – DERP INSTRUCTION

DoD Instruction (DoDI) 4715.07, *Defense Environmental Restoration Program (DERP)*, May 21, 2013

- Establishes policies, assigns responsibilities, and provides procedures for implementing the DERP
- Establishes DoD's Interim Risk Management (IRM) policy
  - Implement IRM, when appropriate, to reduce potentially significant threats to human health at sites where DoD is not expected to conduct an investigation, removal action, or remedial action for an extended period of time
- Designates the Secretary of the Army as lead agent for the FUDS program
  - Army identifies FUDS program funding requirements, conducts cleanup activities at eligible properties, and reports on progress
- Establishes the DoD Cleanup Committee
  - DoD established the FUDS Forum Working Group under the DoD Cleanup Committee

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THE REALLY BIG PICTURE – DERP MANAGEMENT

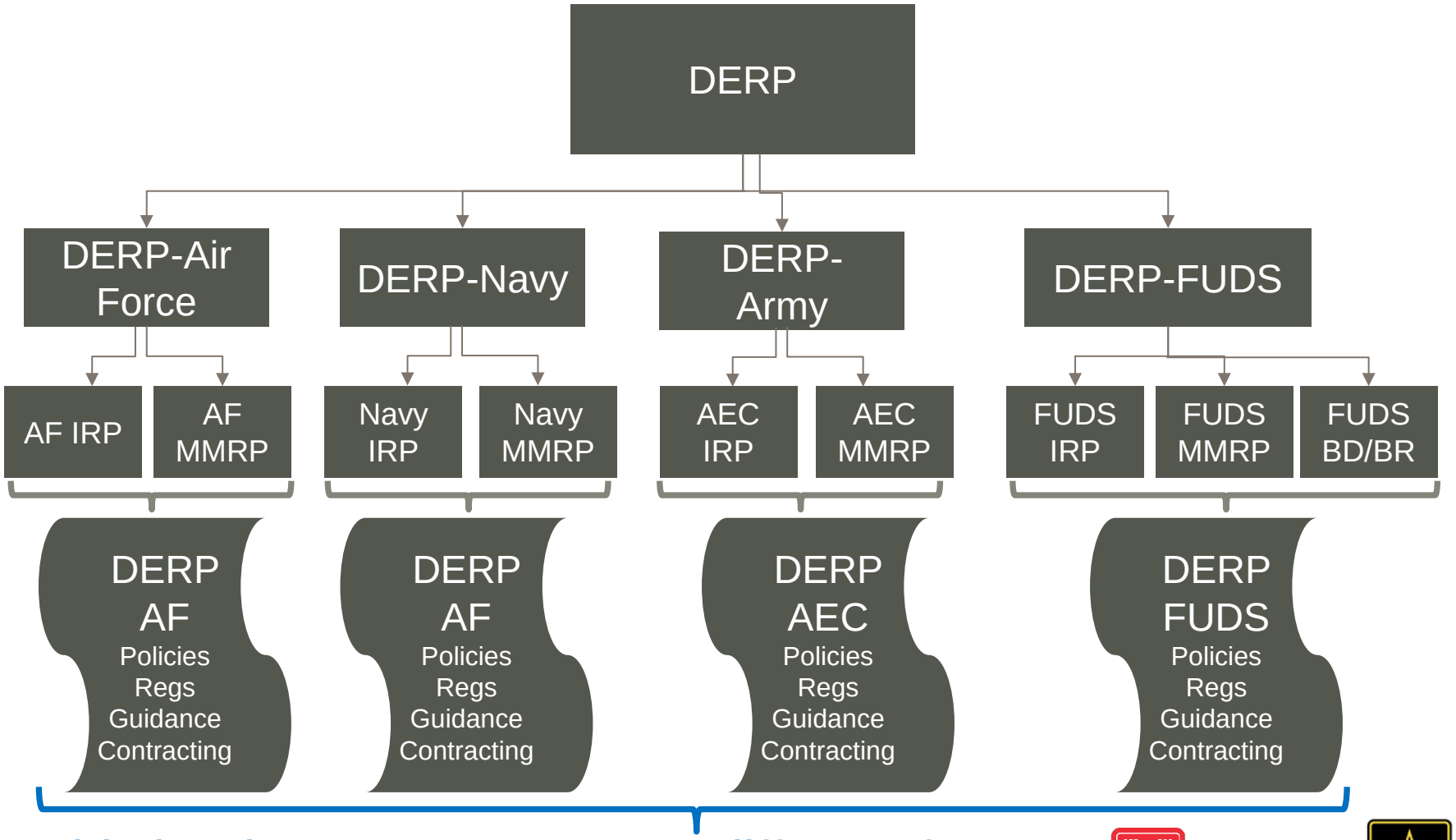
DoD Manual (DoDM) 4715.20, *Defense Environmental Restoration Program (DERP) Management*, March 9, 2012

- Outlines procedures and provides further guidance on the policies in DoDI 4715.07, including:
  - Environmental Restoration Account Funding
  - DERP Eligibility
  - Environmental Liability and Cost-To-Complete (CTC) Management
  - Federal Facility Agreements
  - Response Complete (RC) Determinations
  - Green and Sustainable Remediation
  - Defense State Memorandum of Agreement (DSMOA) Eligibility
  - Vapor Intrusion
  - Administrative Record Keeping
  - 5-Year Reviews
  - Restoration Advisory Boards
  - Land Use Controls

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THE REALLY BIG PICTURE – DERP MANAGEMENT



This is why you get so many different format!

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QUICK LOOK AT FUDS

A NEW FUDS VISION:

"RESPONSE COMPLETE IN OUR LIFETIME"

FUDS Guiding Principles:

1. ***Goal Focused:*** Focus our efforts on leveraging annual funding towards achieving DoD IRP goals of 90% Response Complete by the end of FY18 and 95% Response Complete by the end of FY21.
2. ***Creativity:*** Pursue progressive acquisition strategies to address multiple FUDS projects and phases under coordinated procurements that are based on well-defined and achievable objectives.
3. ***Innovation:*** Effectively assess and implement advanced geophysical classification at all phases of the CERCLA process at FUDS MMRP projects in order to reduce both time and costs for munitions cleanup.
4. ***Fiscal Responsibility:*** Plan, resource, and execute FUDS projects based on a commitment to complete the RI/FS phase of work to within four to five years of initiation.
5. ***Commitment to Excellence:*** Maximize the assignment of qualified, trained, and experienced FUDS project management, technical, and support staff to serve on high performing virtual PDTs that cross traditional boundaries.
6. ***Continuous Improvement:*** Integrate innovative technology and optimization processes to reduce time and costs to achieve Response Complete for ongoing FUDS projects with RA-C and RA-O phases with durations greater than five years.
7. ***Collaboration:*** Elevate regulatory and stakeholder disagreements and delays quickly up the chain of command in order to resolve through tiered partnering or to support timely decision making to implement response actions under our DERP authorities even when regulatory or stakeholder concurrence cannot be achieved.
8. ***Transparency:*** Share information and findings with our regulators, stakeholders, and public and support collaborative engagements that address issues and uncertainties as part of the decision-making process.

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LINKS TO FUDS INFO

- DOD DENIX FUDS Page:
  https://denix.osd.mil/fuds/overview/
- USACE FUDS Home Page:
  http://www.fuds.mil
- USACE FUDS Public GIS Page:
  http://maps.crrel.usace.army.mil:7778/publicfuds/
- USACE FUDS Forum Community Portal:
  https://www.fudsforum.org/

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WHAT IS A FUDS?

Definition: Real property that was under the jurisdiction of the Secretary and owned by, leased to, or otherwise possessed by the U.S. and those real properties where accountability rested with DoD but the activities at the properties were conducted by contractors that were transferred from DoD control prior to October 17, 1986.

There are three types of FUDS:

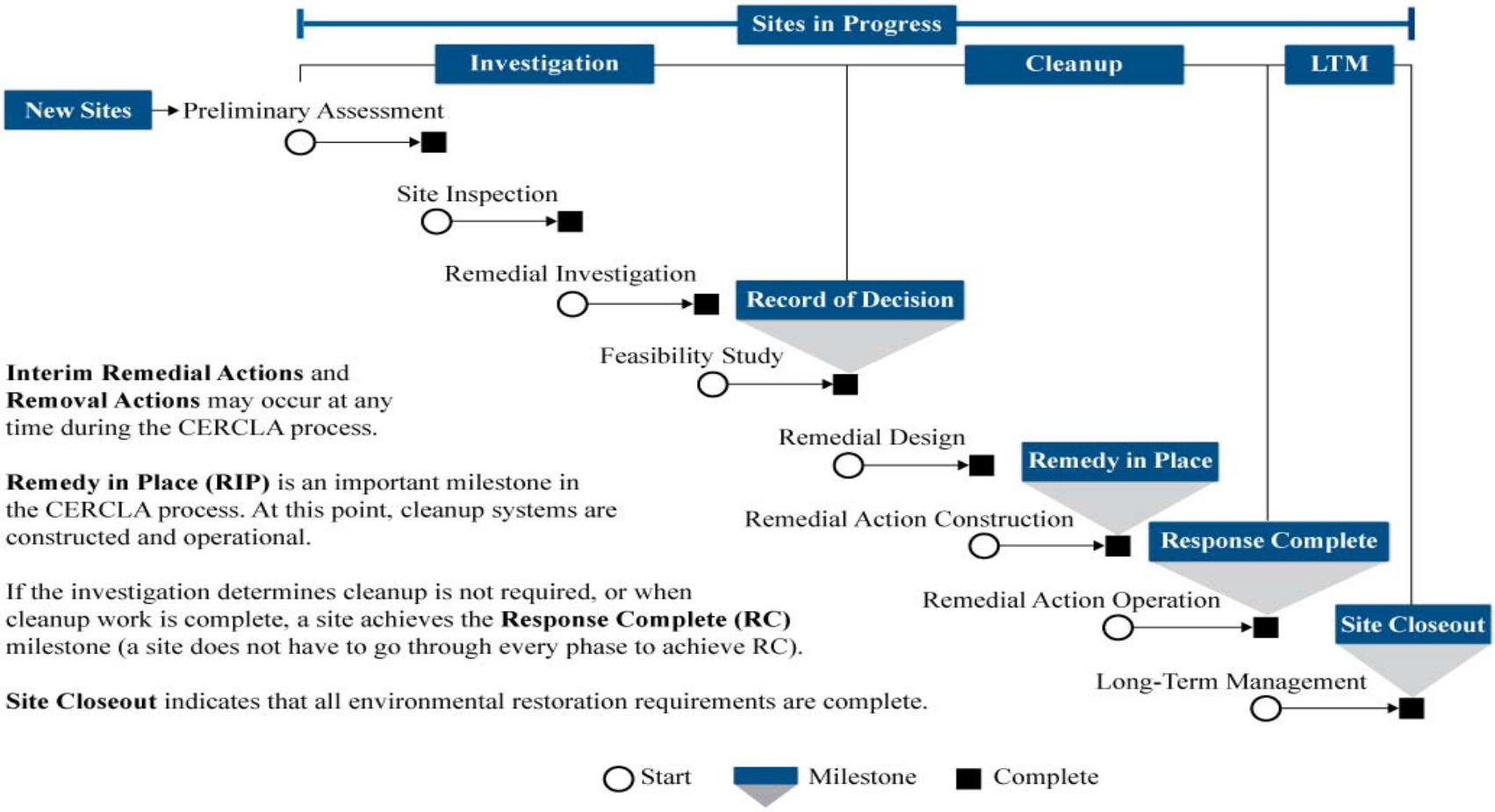
- Instalation Restoration
- Building Demolition/Building Removal
- Military Munitions Response Program

Mission: The mission for the FUDS Program is to employ a risk management approach to perform appropriate, cost-effective cleanup of contamination caused by the Department of Defense and to protect human health, safety, and the environment.

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CERCLA PROCESS



Interim Remedial Actions and **Removal Actions** may occur at any time during the CERCLA process.

Remedy in Place (RIP) is an important milestone in the CERCLA process. At this point, cleanup systems are constructed and operational.

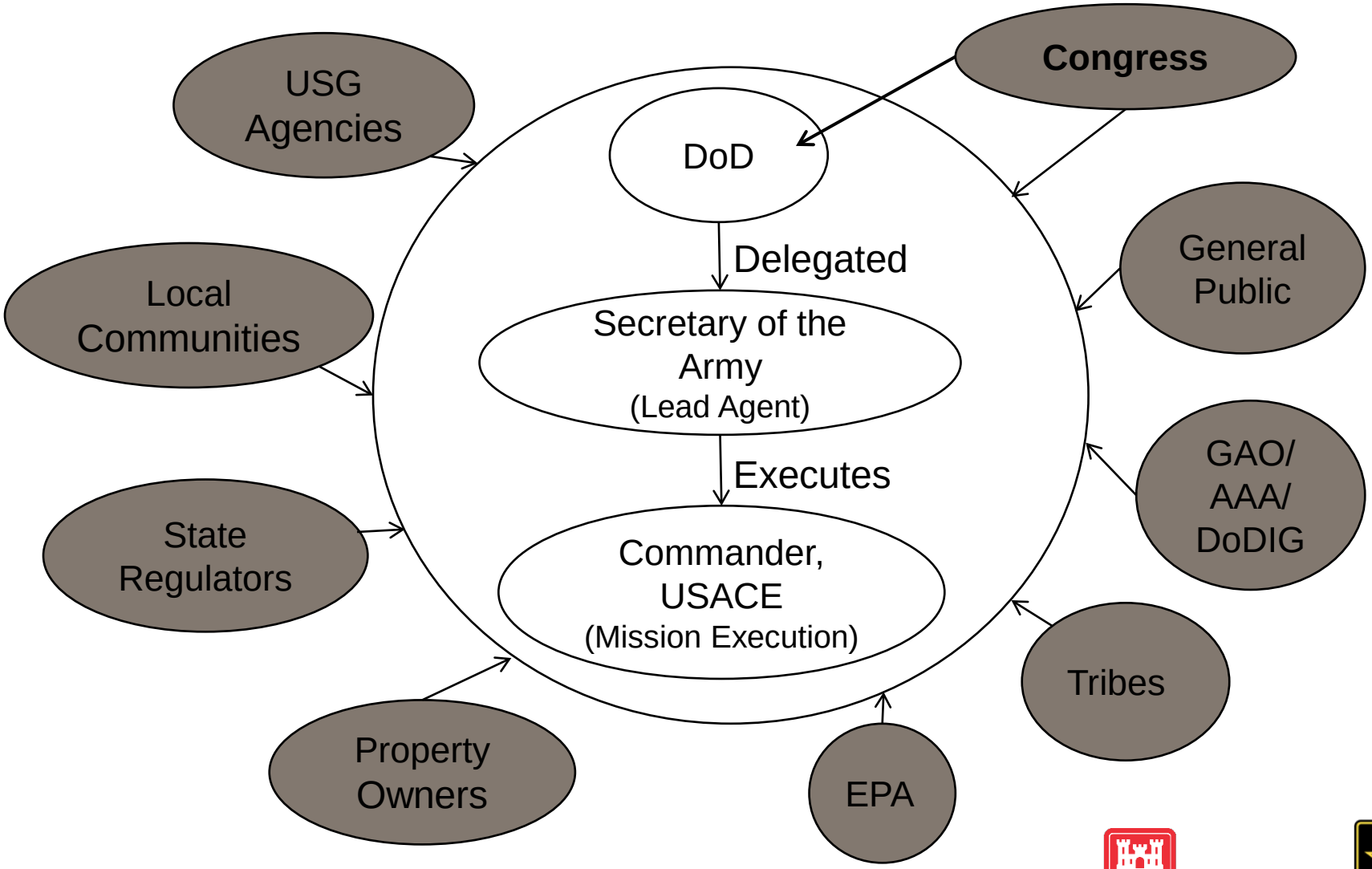
If the investigation determines cleanup is not required, or when cleanup work is complete, a site achieves the **Response Complete (RC)** milestone (a site does not have to go through every phase to achieve RC).

Site Closeout indicates that all environmental restoration requirements are complete.

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FUDS STAKEHOLDERS

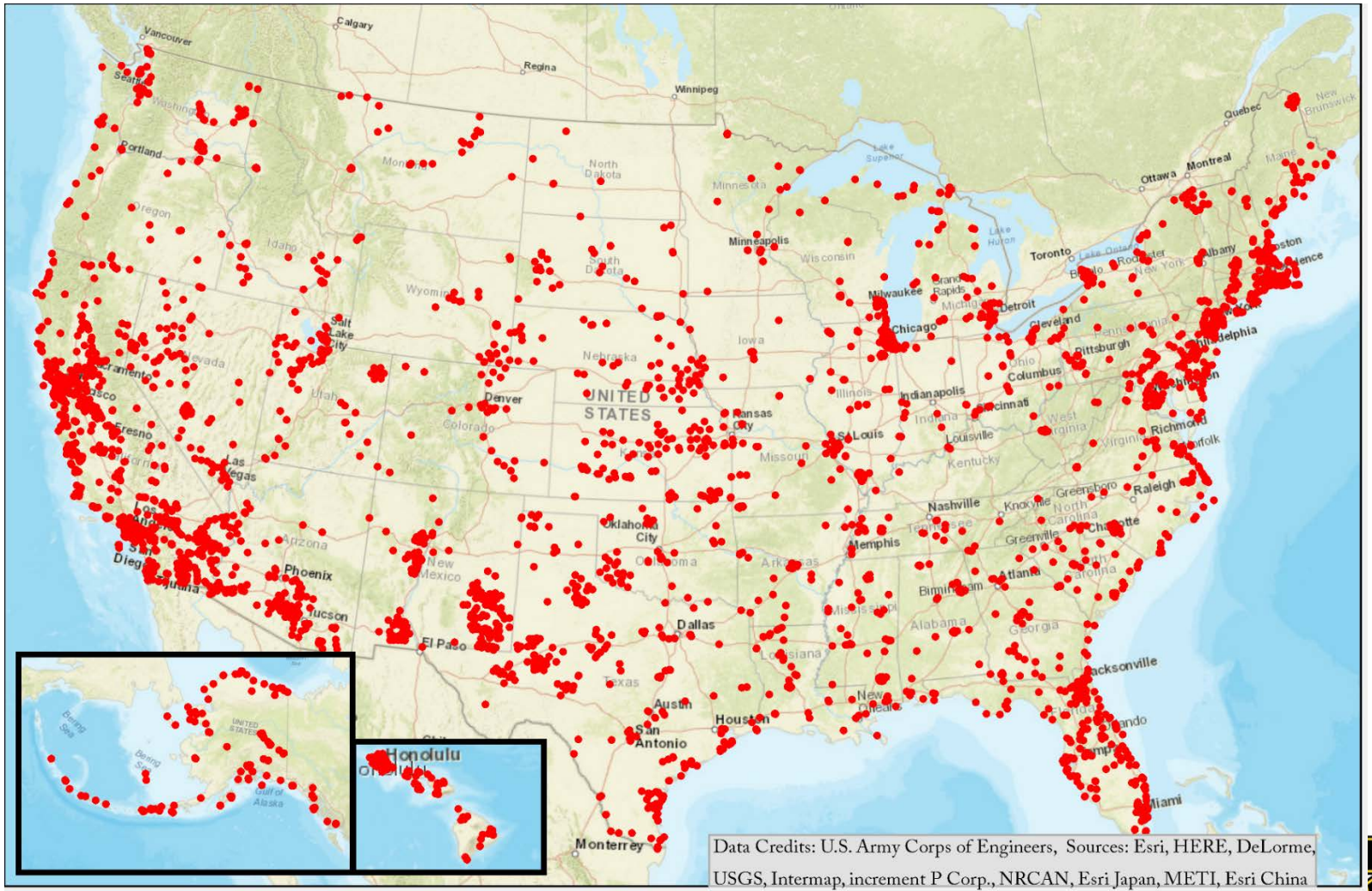


US Army Corps of Engineers

U.S.ARMY

LOCATION OF FUDS SITES

Total Number of FUDS Project: 5,144
Note: Territories are not shown

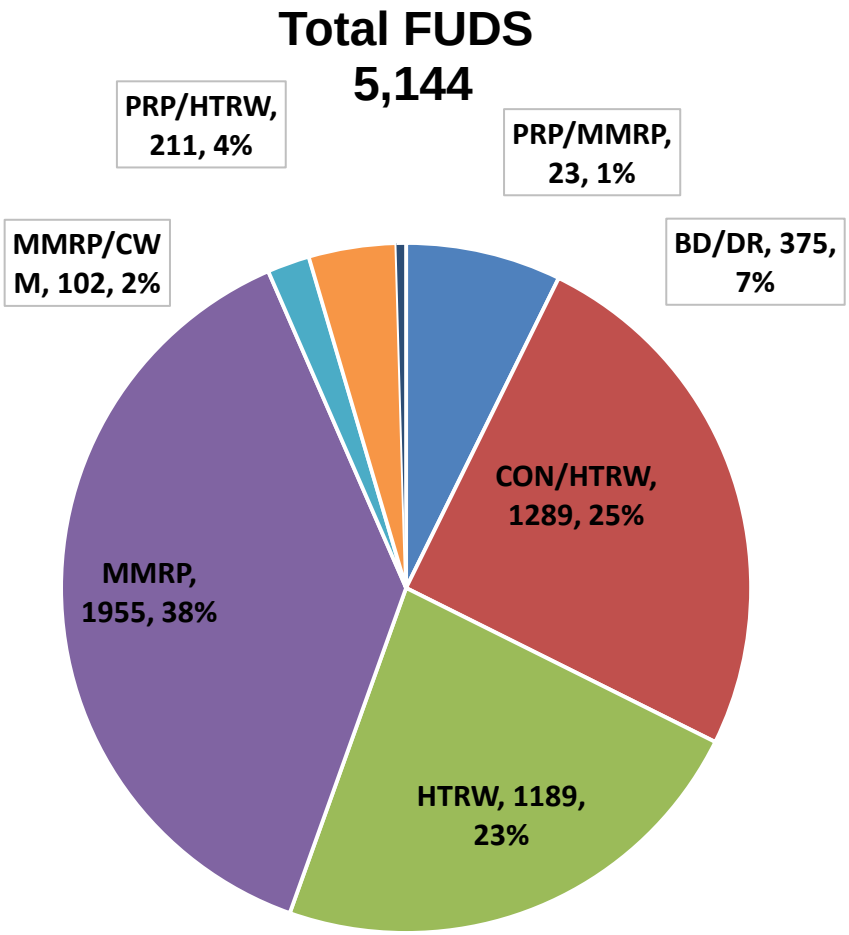


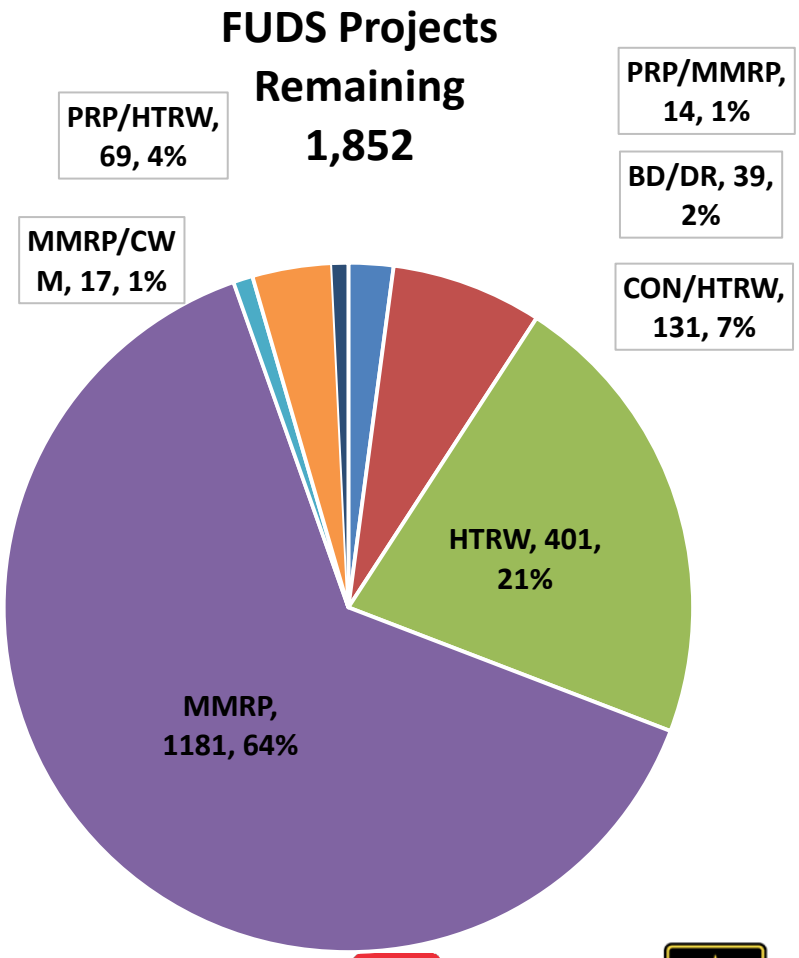
US Army Corps of Engineers

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As of 30 Sept 2015

FUDS PROJECT DISTRIBUTION (AS OF 30 SEP 15)



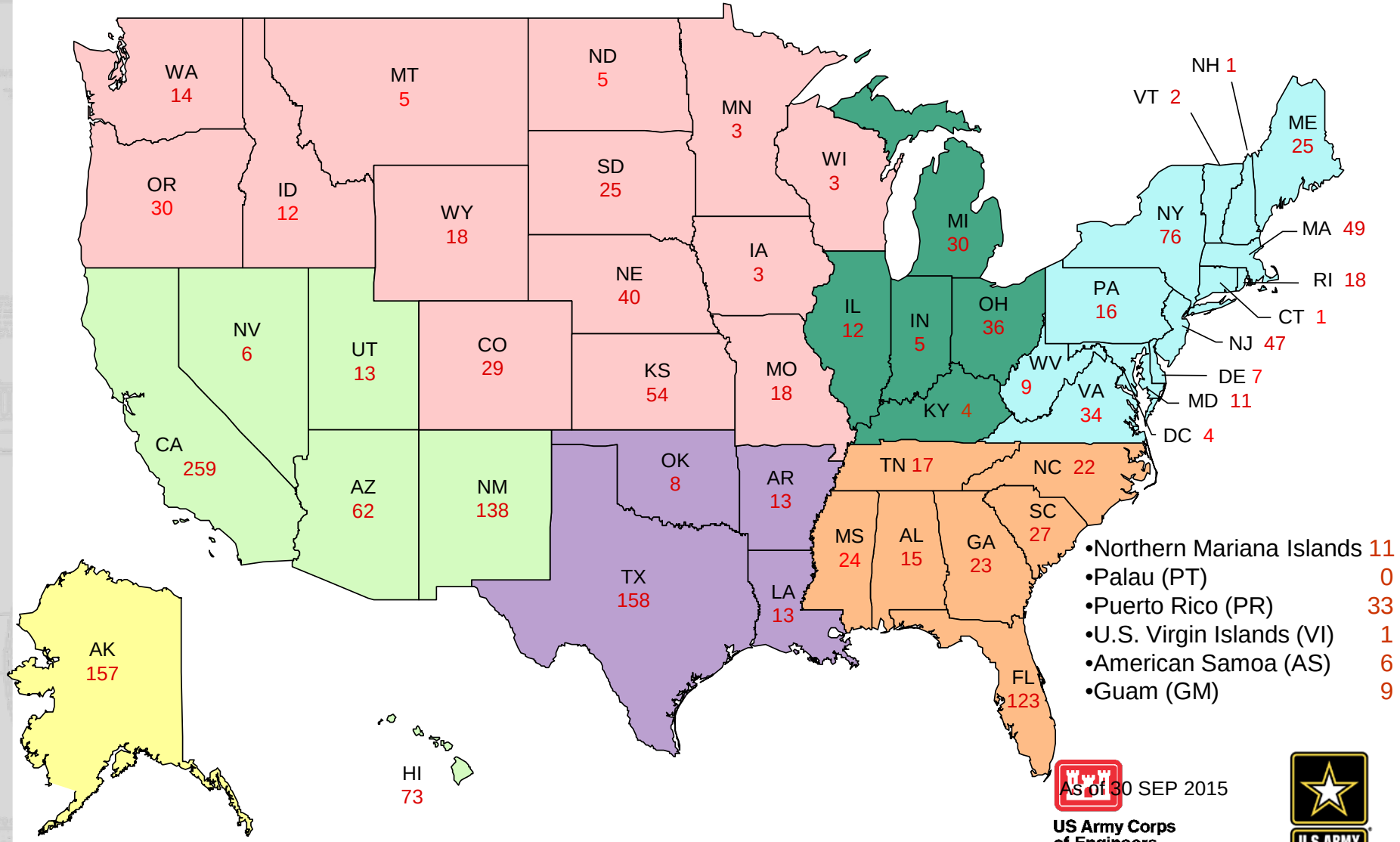


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Remaining FUDS Projects

Remaining FUDS Projects not at RC: 1,852 [IRP – 640/ MMRP – 1,212]



- Northern Mariana Islands 11
- Palau (PT) 0
- Puerto Rico (PR) 33
- U.S. Virgin Islands (VI) 1
- American Samoa (AS) 6
- Guam (GM) 9

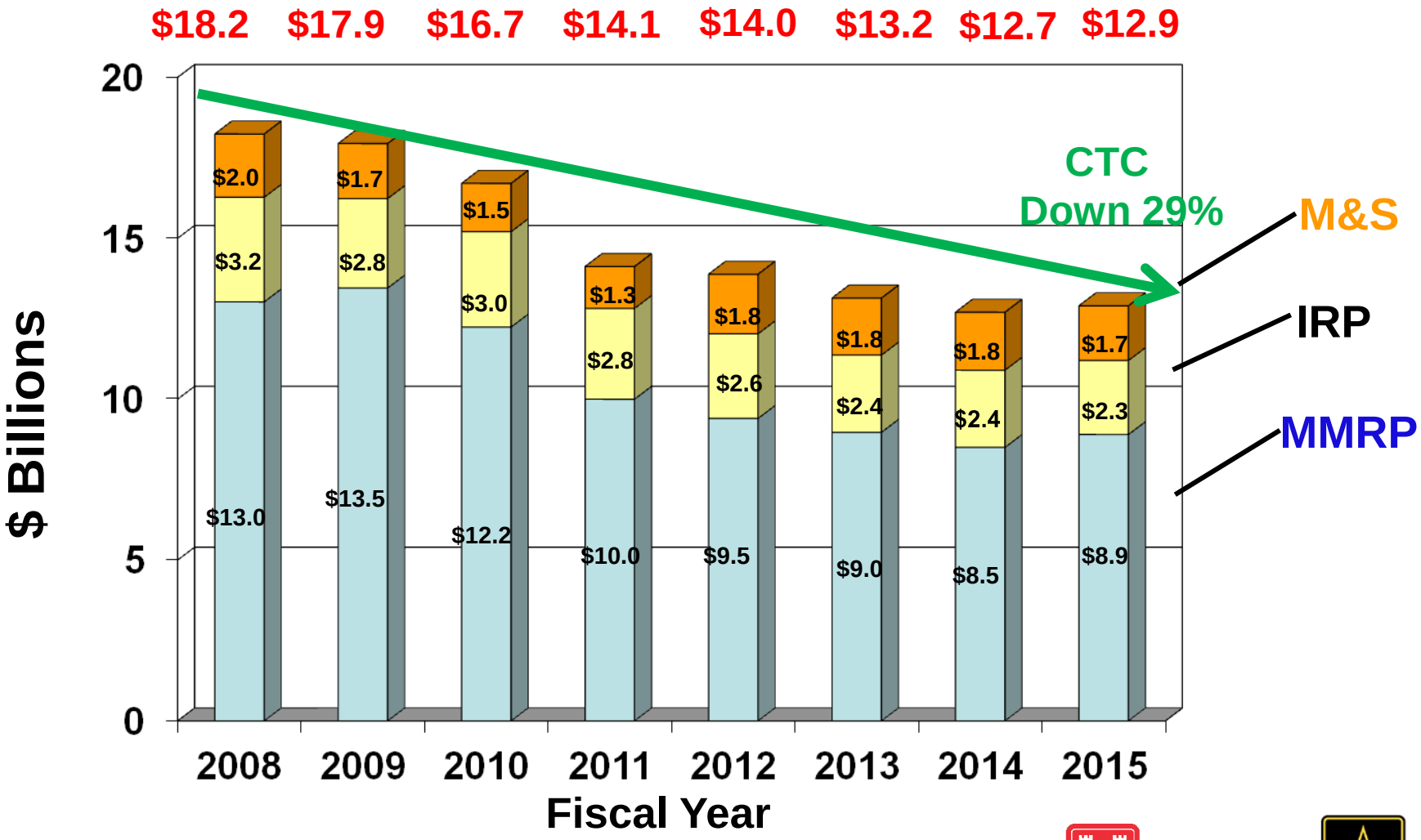
As of 30 SEP 2015

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FUDS Program CTC (FY* & Beyond)

(IRP = HTRW + CON/HTRW + BD/DR)



*Dollars shown reflect CTC reported amounts (not adjusted for inflation)

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OSD GOALS FOR FUDS

- **Installation Restoration Program (IRP):**
  - Achieve Response Complete at 90% of IRP and BD/DR sites on FUDS by the end of FY2018
  - Achieve Response Complete at 95% of IRP and BD/DR sites on FUDS by the end of FY2021
- **Military Munitions Response Program (MMRP):**
  - Implement Interim Risk Management (IRM) or initiate a Munitions Response action, to include an investigation or a removal/remedial action at FUDS MRS that have not yet reached Response Complete for 90% of the FUDS MRS inventory by the end of FY2018

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FUDS STATUS

IRP & BD/DR Sites	FY10 Actual	FY15 Actual	FY16 Planned	FY18 Projected	FY21 Projected
Sites Remaining	734	571	502	325	169
Sites at RC	73%	80%	82%	89%	94%
MMRP Sites	**FY10 Actual**	**FY15 Actual**	**FY16 Planned**	**FY18 Projected**	**FY21 Projected**
Sites Remaining	1054	1198	1185	1148	1135
Sites at RC	38%	42%	42%	44%	45%

Data as of 30 September 2015

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FUDS PROPERTIES MMRP COST TO COMPLETE (CTC)

- EOY2015 CTC $9.00B
- Net Change (+/-) in CTC from EOY2014 to EOY2015 +$70M

So Why Advanced Geophysical Classification?

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COMPETITION TIME

Need Two Volunteers

- Right Side / Left Side
- Good in Counting Theory
- There will be a prize

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IN 2000, BEFORE CLASSIFICATION (BC)



8

>50

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AND THEN THERE WAS…



ADVANCED GEOPHYSICAL CLASSIFICATION

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IN 2016, AFTER CLASSIFICATION (AC)



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ADVANCED GEOPHYSICAL CLASSIFICATION (AGC) & USACE

- AGC Technologies were used at 14 Munition Response Sites (MRSs) at 9 properties in 2015. Properties have been mainly in the Remedial Investigation/Feasibility Study (RI/FS) phase or Removal Action – Construction (RmA-C) phase.
  - Buckley Field, Camp San Luis Obispo, Culebra (4 Projects), Marpi Point Field, Mount Owen Rifle Range, Raritan Arsenal, Scioto Ordnance Plant, Waikoloa Maneuver Area (4 Projects), Ft. Ord

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ESTCP CLASSIFICATION DEMONSTRATION SITES

Our Industry's Treatability Study



20 demonstration sites

Over 30 datasets from 3 different sensors

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BENEFITS SUMMARY: THE MMRP AGC EPIPHANY

- Cheaper
  - Dig MEC, not MD
- Better
  - QC / QA for AGC
  - Confidence in Decisions
- Faster
  - Contracting Consistency
  - Performance Consistency
- Greener
  - Fewer needless digs
  - Smaller project carbon footprint



ADDITIONAL TRAINING AND RESOURCES

- SERDP/ESTCP website contains webcasts, tutorials, and demonstration reports on the classification technology
  - www.serdp-estcp.org
- ESTCP Technology Transfer Workshops
- M2S2 Webinar Series
  - http://www.clu-in.org/conf/tio/m2s2fy16-2_042116/
  - http://www.clu-in.org/conf/tio/m2s2fy15-2_022615/
  - http://www.clu-in.org/conf/tio/m2s2fy14-3_022514/
  - http://www.clu-in.org/conf/tio/m2s2-3_042213/



- Interstate Technology Regulatory Council (ITRC) Geophysical Classification For Munitions Response: http://www.itrcweb.org/gcmr-2/
  - Archived web training: https://clu-in.org/conf/itrc/GCMR_011416/

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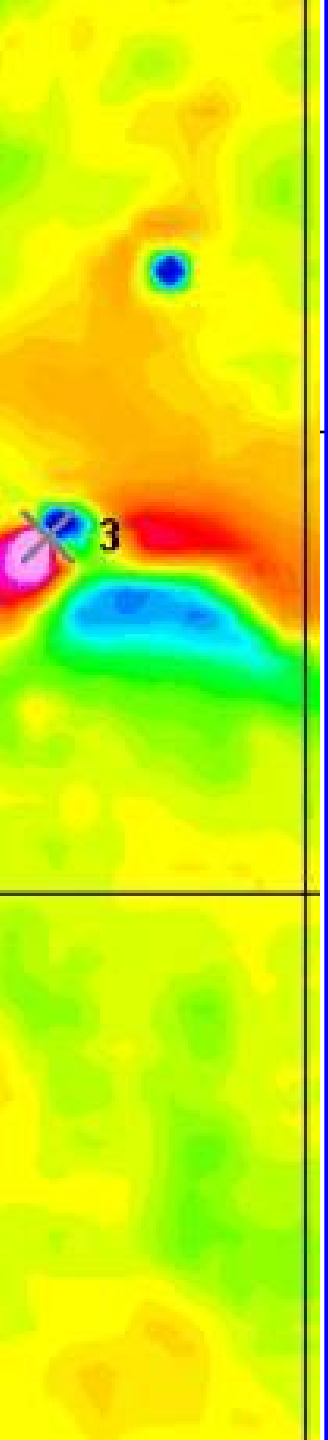
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QUESTIONS?



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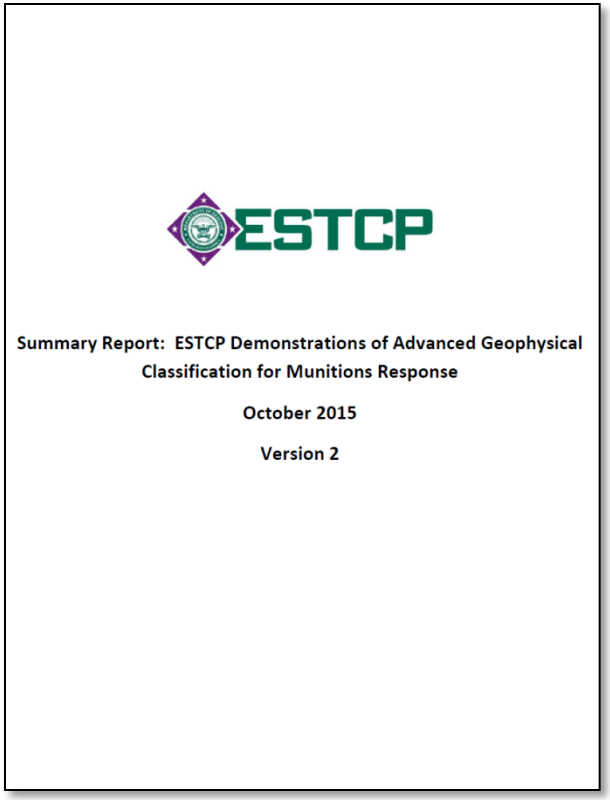


Topic 3 – Summary of ESTCP Demonstrations 2007 to Now

Bryan Harre
NAVFAC EXWC

Enabling Objectives

- Identify investigation/removal site types where advanced geophysical classification was performed
- Discuss munitions types and combinations of munitions used at the demonstration sites
- Describe the anomaly density and geologic noise that can impact classification performance
- Explain the cost savings that advanced geophysical classification can provide



ESTCP Demonstration Sites

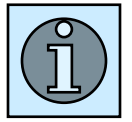


ESTCP-sponsored demonstrations
at over 25 sites

Summary of Demonstration Sites

Degree of Difficulty	Characteristics	Example Demonstration	Expectation
Easy	Limited munitions types, low anomaly density, terrain and vegetation allow for high quality data collection, no geologic interference	Pole Mountain, WY Camp George West, CO SW Proving Ground, AR	Almost all analysts correctly classify all seeds, eliminate ~90% of the clutter from the final dig list
Typical	Mixed munitions, none smaller than 37-mm, low to moderate anomaly density, , terrain and vegetation allow for high quality data collection, moderate geology	Spencer Range, TN Camp Beale, CA	Most analysts correctly classify all seeds, eliminate ~70% of the clutter from the final dig list
Difficult	Mixed munitions, smaller than 37-mm TOI, high anomaly anomaly density, , conditions make data collection challenging, complex geology	Massachusetts Military Reservation, MA	Even the most skilled analysts may not detect all TOI, eliminate ~50-70% of the clutter from the final dig list

Expectations for Easy, Typical, and Hard Sites



Demonstrator Results

- Not all demonstrators are equal
  - Major reason DoD has implemented the DoD Advanced Geophysical Classification Accreditation Program (DAGCAP)



Photo courtesy of ESTCP.

Munitions Types and Combinations of Munitions

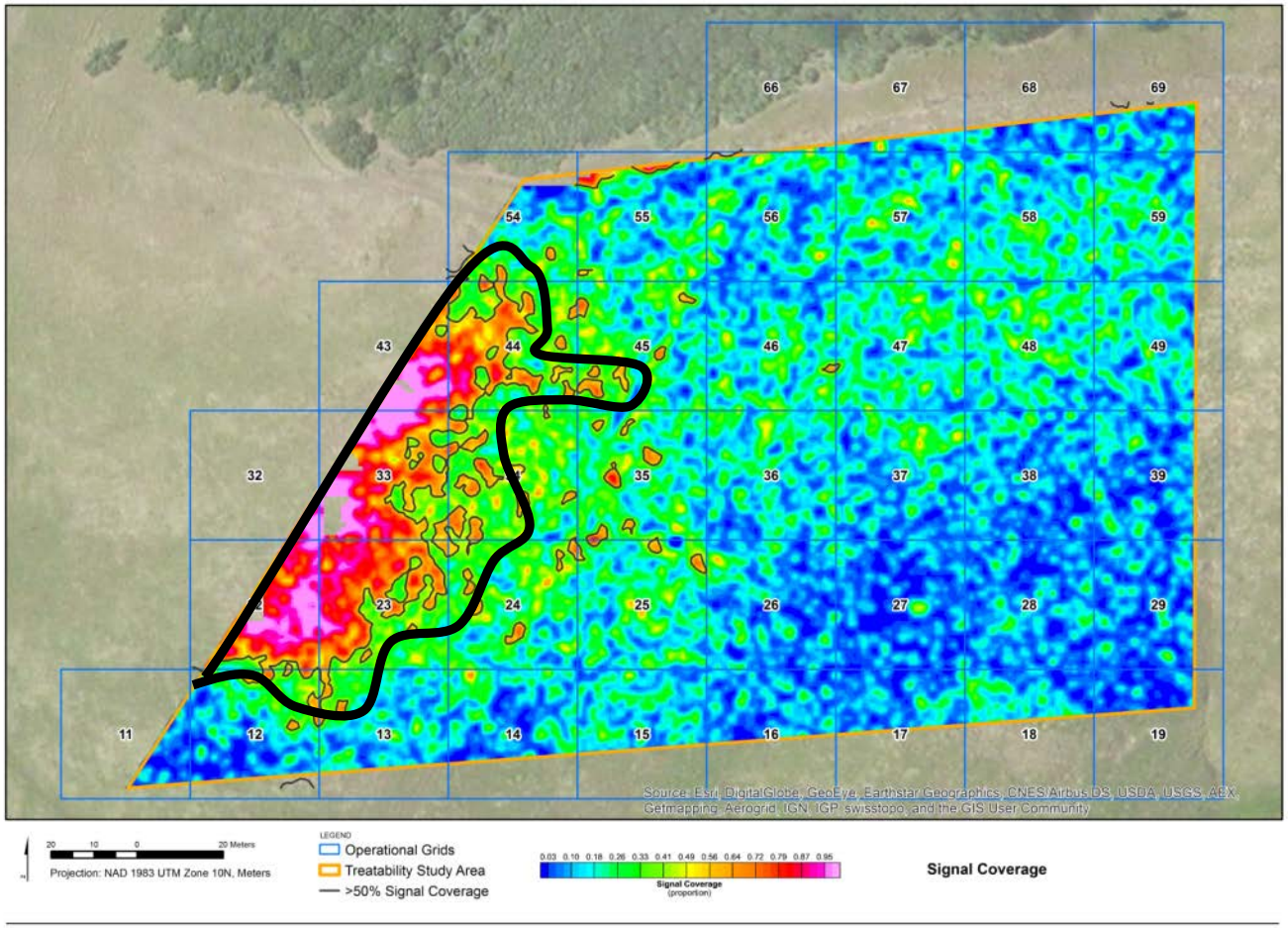
- Larger munitions are easier to classify than smaller munitions and classification is easier on sites with fewer different types of munitions.
- Smaller 37mm look more similar to the clutter to the sensor, particularly the fragments left by the detonation of larger items
- 20mm look even more like clutter and will impact the economics of using classification
- 37mm projectiles combined with other larger munitions are routine to classify



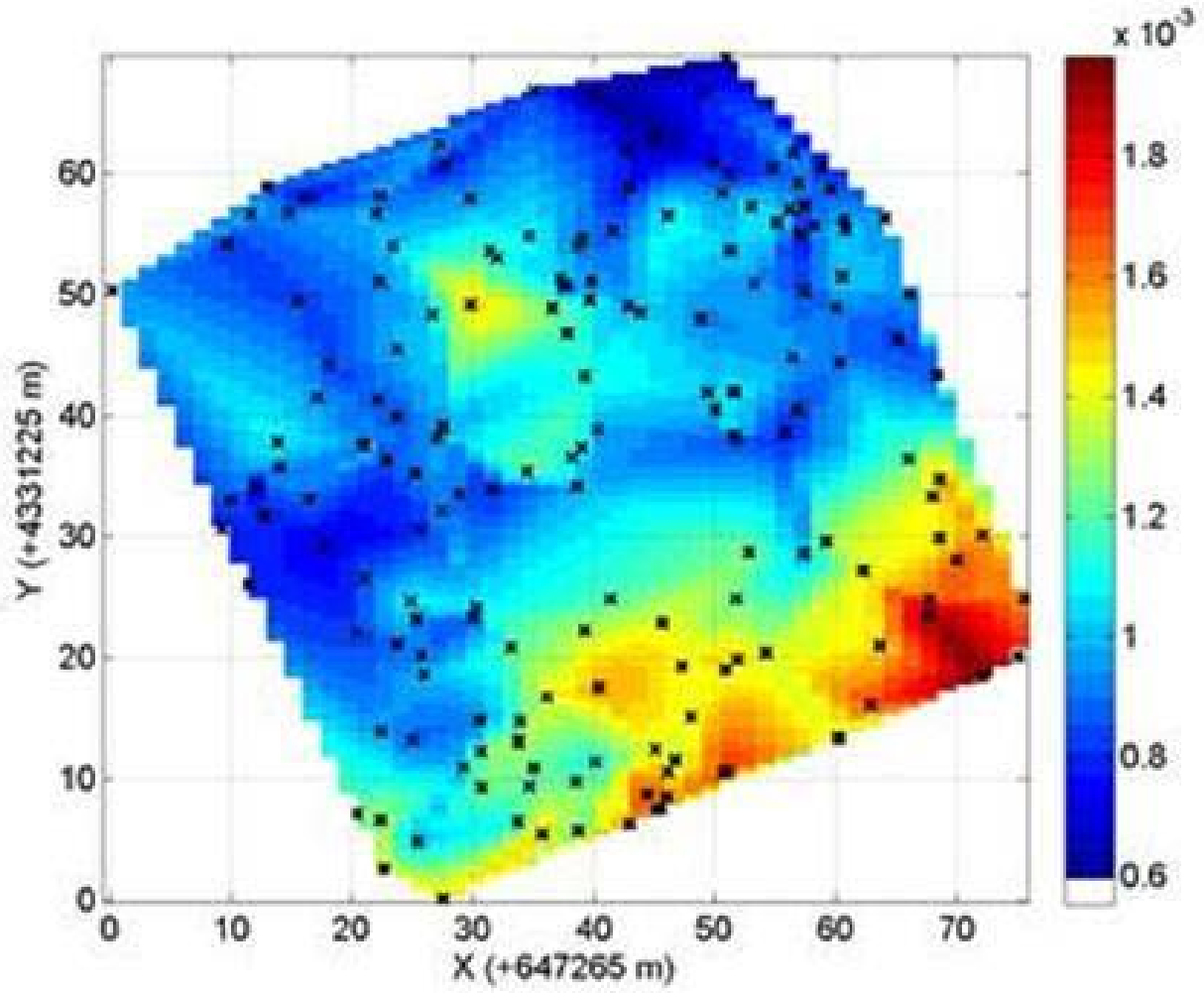
ISO80 and 37mm Projectile. Photo courtesy of ESTCP.

Anomaly Density

- Detection survey typically used by project team to identify areas too dense for classification
- Portions of site may require a different approach, i.e. mag and flag or sifting



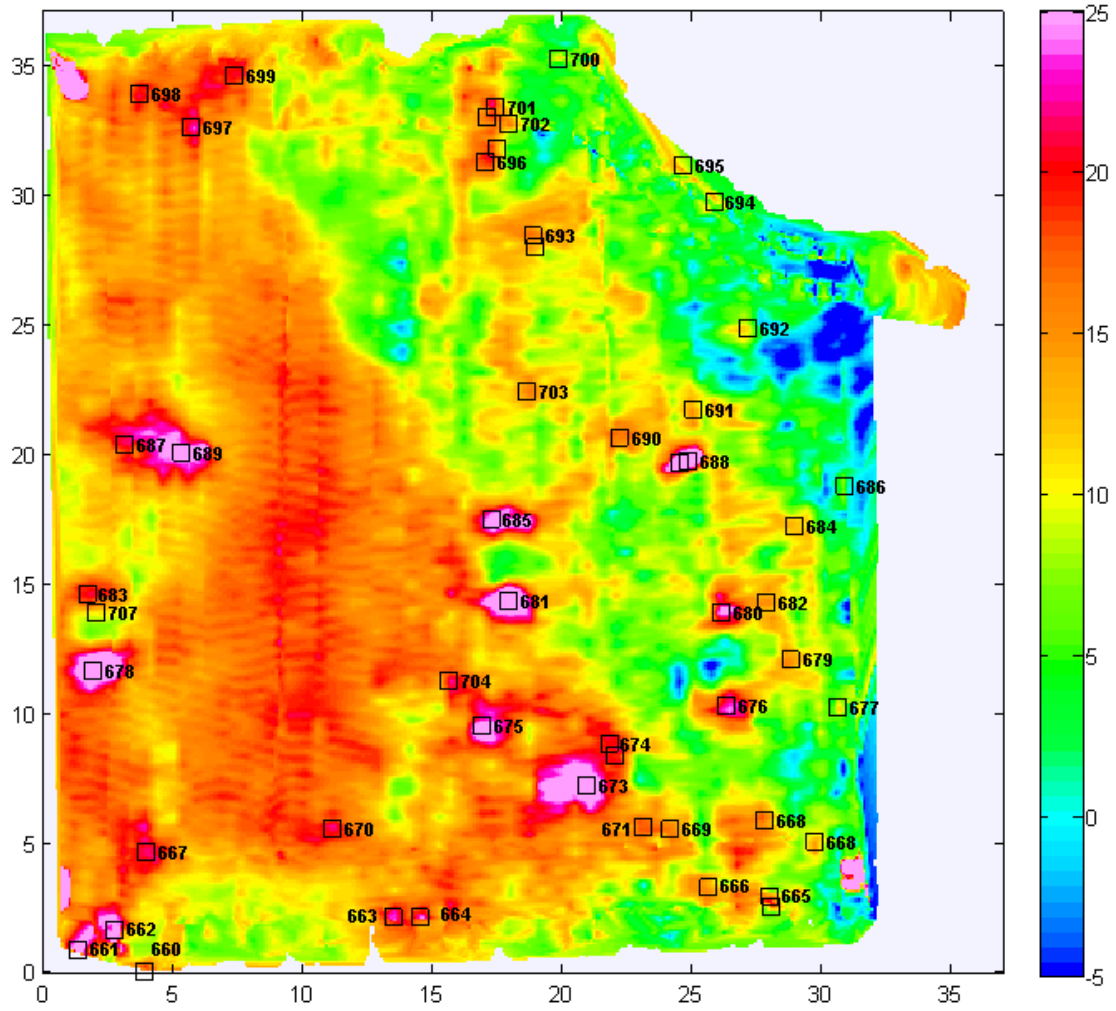
Geologic Background Variation (1)



Geologic Background Variation at the former Camp Beale

Graphic courtesy of ESTCP.

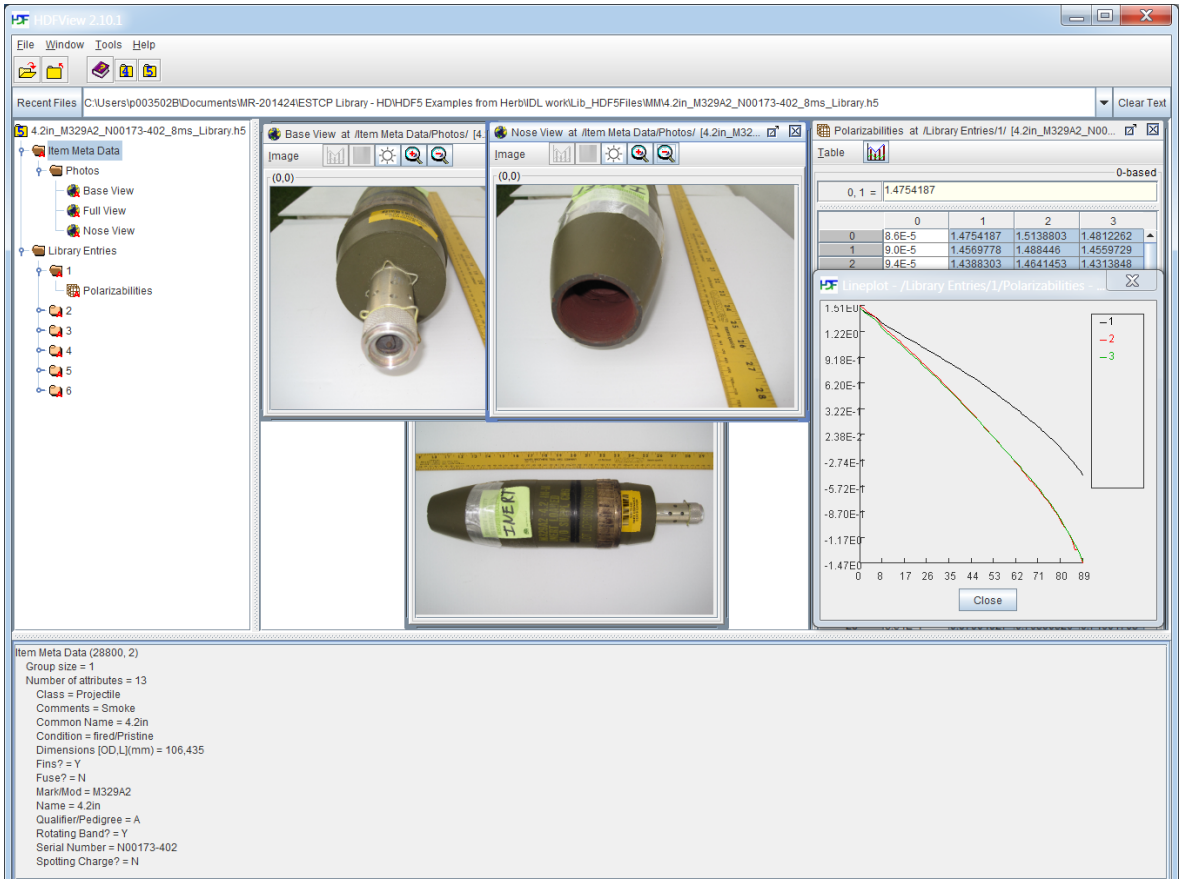
Geologic Background Variation (2)



Geologic Background Variation at Waikaloa

Graphic courtesy of ESTCP.

Target of Interest (TOI) Signature Library



Collection of TOI signatures:

1. Metadata,
2. Sensor data
3. Polarizations

ESTCP generated
DOD maintained

Unexpected Munitions

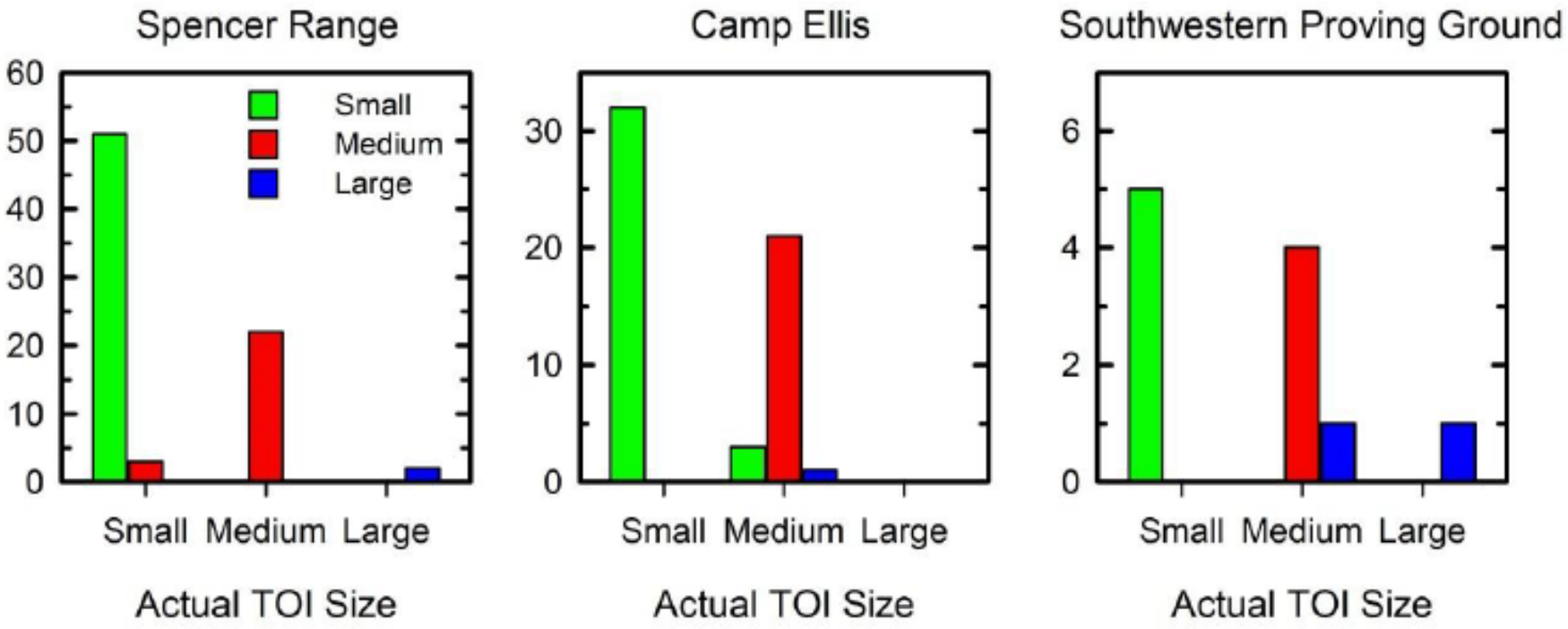
- Beale – Digging uncovered a number of fuze parts that had not previously been identified. Explosives safety experts determined that these fuze parts were not hazardous, and not a TOI.
- Fort Sill – Presence of six “hollow steel ball assemblies,” which are hazardous components of the 40-mm grenades known to be present on the site.
- Involve Explosives Safety Specialists early in the planning process, and transmit knowledge of hazardous components to the analysts.
- Classification is robust to the presence of unexpected munitions on the site and procedures to process the data are now standardized.



T-Bar Fuze
Non-hazardous clutter

Munitions Size

- Classification can identify the approximate size of munition
- Significant Benefit in reducing the Explosives Safety Quantity Distance Arc



Classification by size.

Advanced EMI Sensor developed by ESTCP

Multiple coils measure the complete response of buried items (spatially and temporally)



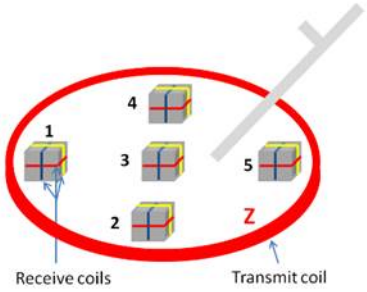
Person-portable

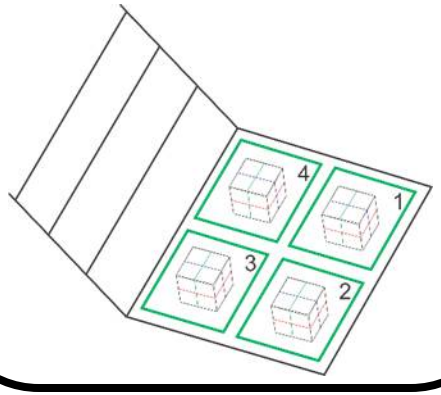


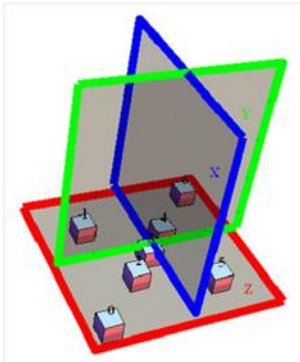
Cart-mounted



Vehicle-towed







Advanced Geophysical Classification Sensors

Sensor	Description	Applicability
MetalMapper	• 1-meter cube • 3-axis transmit • Seven 3-axis 10-cm receive cubes • Continuously samples to 8 ms after transmitter turn-off	• Dynamic and cued modes • Requires vehicle to maneuver • Require GPS • Depth capability similar to EM61 – comparable transmit moment • Commercially available
MetalMapper 2X2	• Four 35-cm transmitters • Four 8-cm, 3-axis receive coils centered in each transmitter • Overall dimension 80cm square • Backpack 15 pounds • Continuously samples to 25 ms after transmitter turn off	• Dynamic and cued modes • Cart and litter-carried deployment • Does not require GPS, but available • Will have less depth capability due to smaller transmit moment • Commercially available
MPV	• 50-cm diameter transmitter – one dimension only • Five 3-axis 8cm receiver cubes • Can be manipulated in 3D to get multiple looks at the target • Carried on a wand, 12 pounds • Continuously samples to 8 ms after transmitter turn off	• Dynamic and cued modes • Small and maneuverable for wooded areas and challenging terrain • Does not require GPS to operate • Uses locating beacon • Will have less depth capability due to smaller transmit moment • Can be contracted through developer

Dynamic Surveys with Advanced Sensors

- Advanced sensors for detection produce data that has higher spatial resolution and allow the use the advanced sensor data to make smarter anomaly selection decisions
- Dynamic data
  - Informed Source Selection, a filtering step is used to identify only those anomalies that could have been caused by a metal object with the characteristics of a TOI, for example one that is well-modeled by a dipole.
  - Make classification decisions using intrinsic target parameters extracted from the dynamic data only.

Lessons Learned - Applicable at Most Sites But Not All

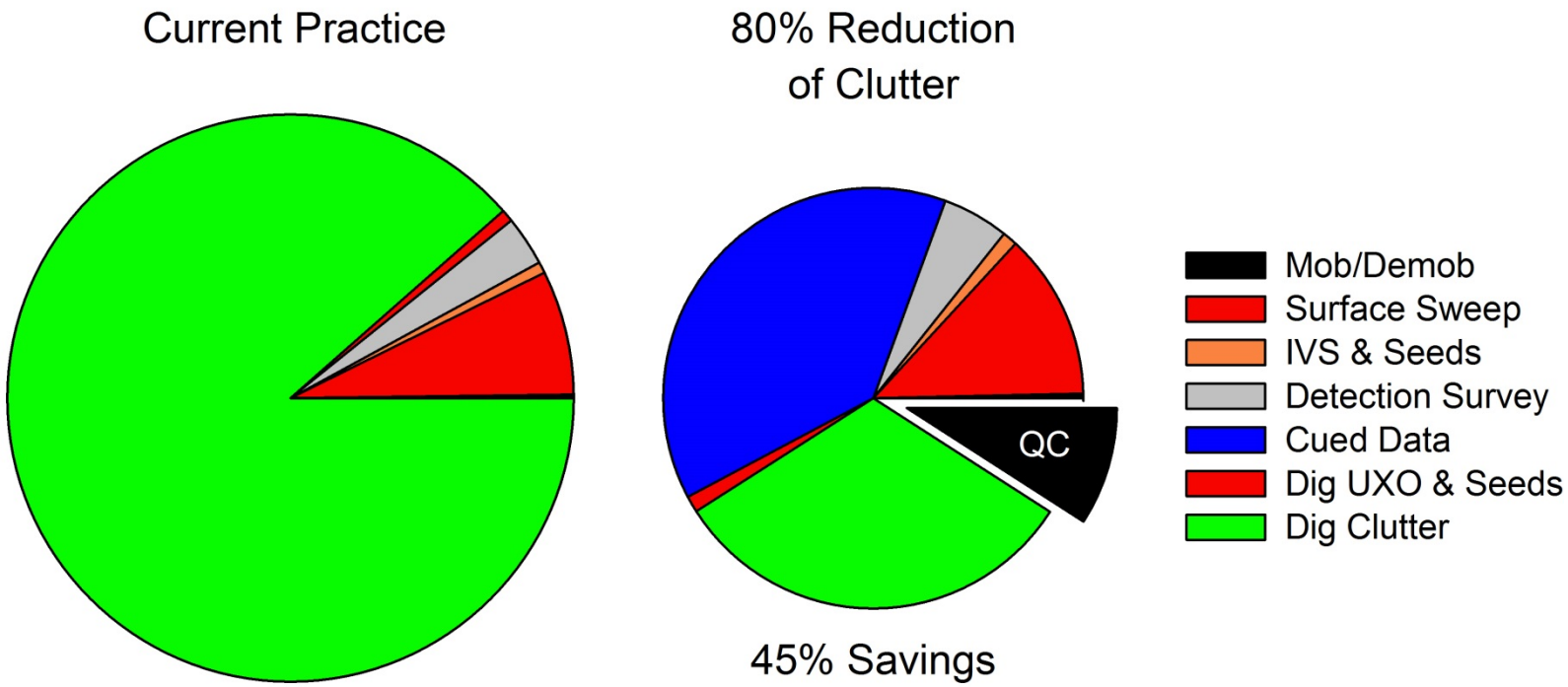


ESTCP-sponsored demonstrations at over 25 sites

Maybe Not Applicable

- Anomaly densities over ~4000 per acre
- Extensive geologic background
- Landfills and disposal pits
- OB/OD areas
- Almost all items are TOI

Potential Savings on a 100-acre Remediation

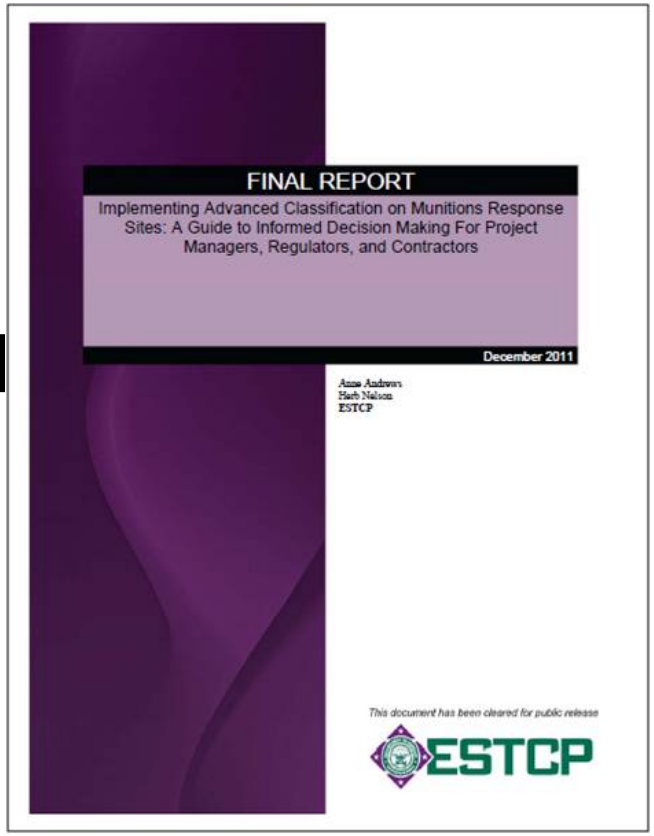


Fun Facts About the Sites

- There are few native TOI on most sites. Their abundance ranged from 0.04% of the total 11 number of items dug at SWPG to 1.5% at Camp George West.
- Depth distribution of the native clutter is very similar for wide range of sites. On all six example sites, the depth distribution peaks in the top 10 cm and on four of the six, the vast majority of clutter was in the top 20 cm.
- Seed plans for the demonstrations, which were meant to put seeds at representative depths, were in fact conservative. Most of the TOI were found at depths shallower than the seeds were emplaced.

Additional Training and Resources

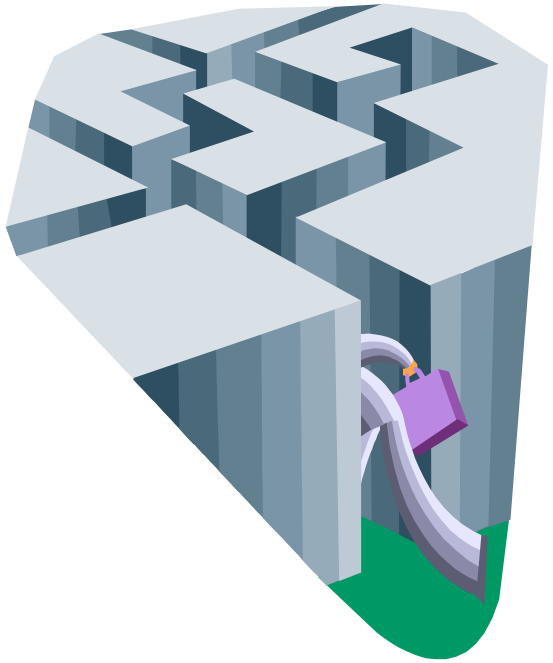
- SERDP/ESTCP website contains webcasts, tutorials, and demonstration reports on the classification technology
  - www.serdp-estcp.org
- ITRC has web document and online training



Summary

- Commercially available sensors - MetalMapper and MetalMapper 2x2 are available for sale or rental
- Analysis Software: The UX Analyze classification software has been incorporated into the GeoSoft Oasis Montaj platform
- Signature Library: ESTCP has assembled a comprehensive library of signatures of common munitions
- Quality Assurance Project Plan: The Environmental Data Quality Work Group, supported by ESTCP, has developed a QAPP template
- Experienced contractors: 10 companies have participated in the ESTCP demonstrations
- Accreditation Program: DoD has mandated an accreditation program for contractors
- Informed regulators: ESTCP has incorporated the input of regulators throughout the demonstration program

Questions



Navy Training Advanced Geophysical Classification

John M. Jackson

Geophysicist

USACE- SPK/EMCX







US Army Corps of Engineers

BUILDING STRONG®

Outline

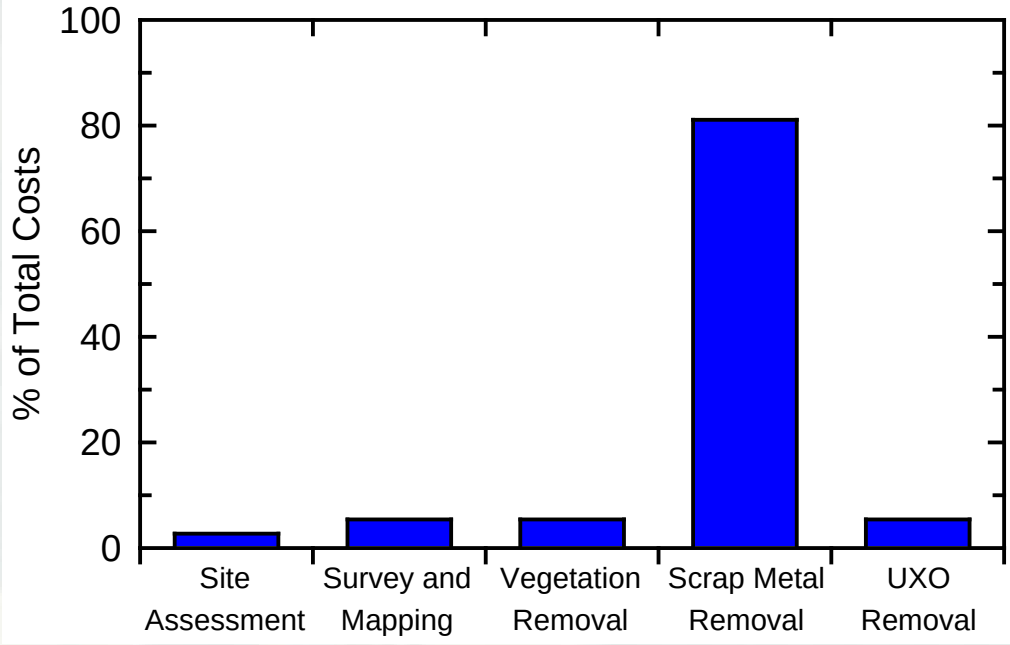
- Why Classification
- How it Works
- Example Workflow and QC/QA – Former Camp San Luis Obispo Example
- Summary

Acknowledgements

- SERDP & ESTCP
- Camp San Luis Obispo PDT
  - CESPL, California EPA, ESTCP, CH2M Hill

Costs Are Dominated By Digging Scrap

- **Often <1% are UXO**
- **Example: Camp Butner, NC**
  - **146 UXO out of >500,000 digs**
  - **Only 0.03% are UXO!**



What Is Classification?

- Attempts to assign an input value to one of a given set of *classes* based on some *attributes* of the input

  à la Wikipedia

  - Is the incoming e-mail “spam” or “not-spam”?
  - Is the buried object that caused this anomaly “UXO” or “not-UXO”?

How Do We Classify Munitions?



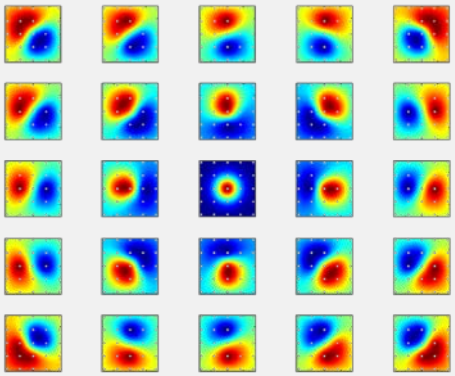
If It's Going To Work…

- It's got to be a principled, data-based approach to classify targets as either "non-hazardous" or "targets of interest"

1. Data Acquisition

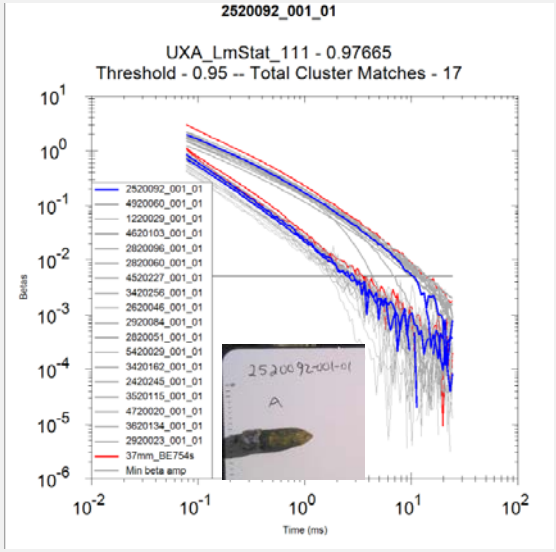


2. Feature estimation



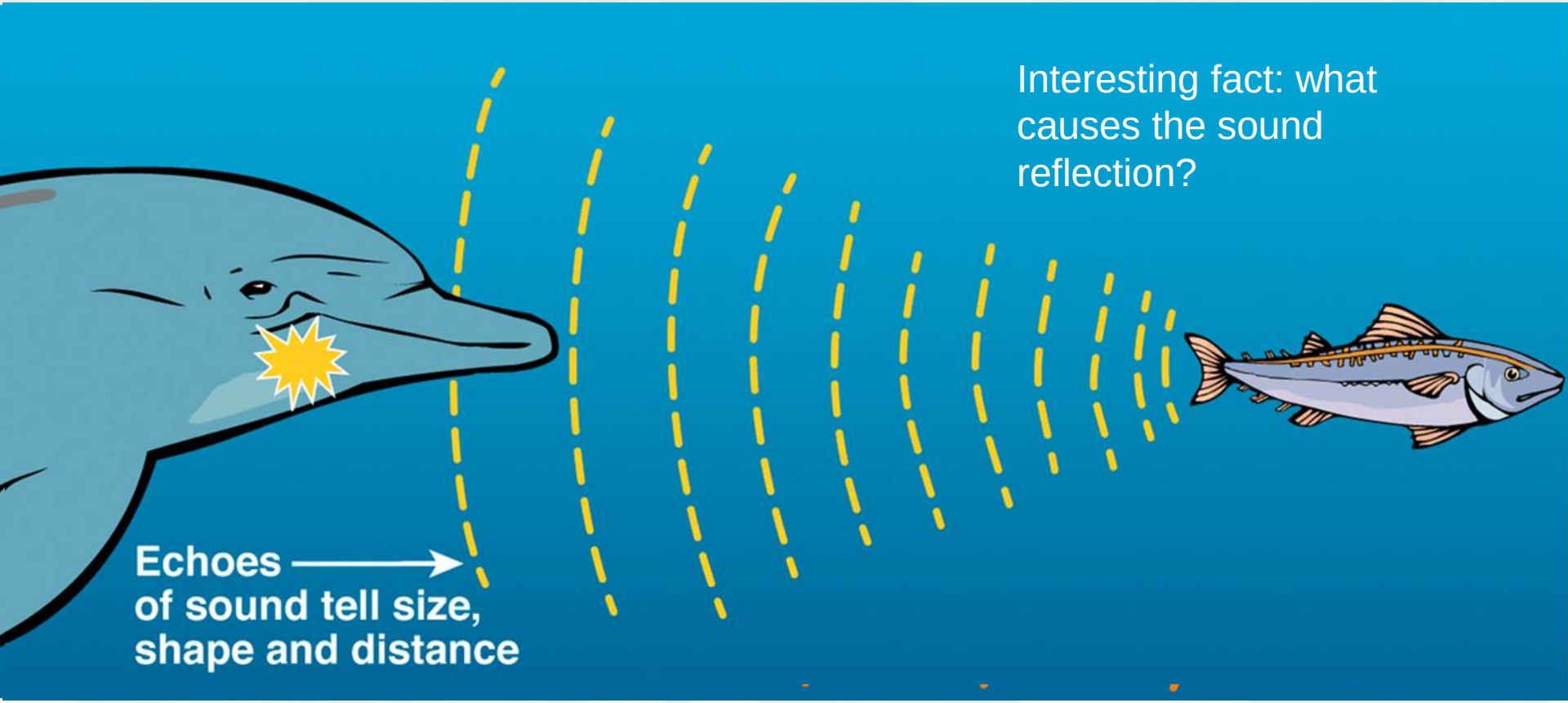
Feature vector

3. Classification



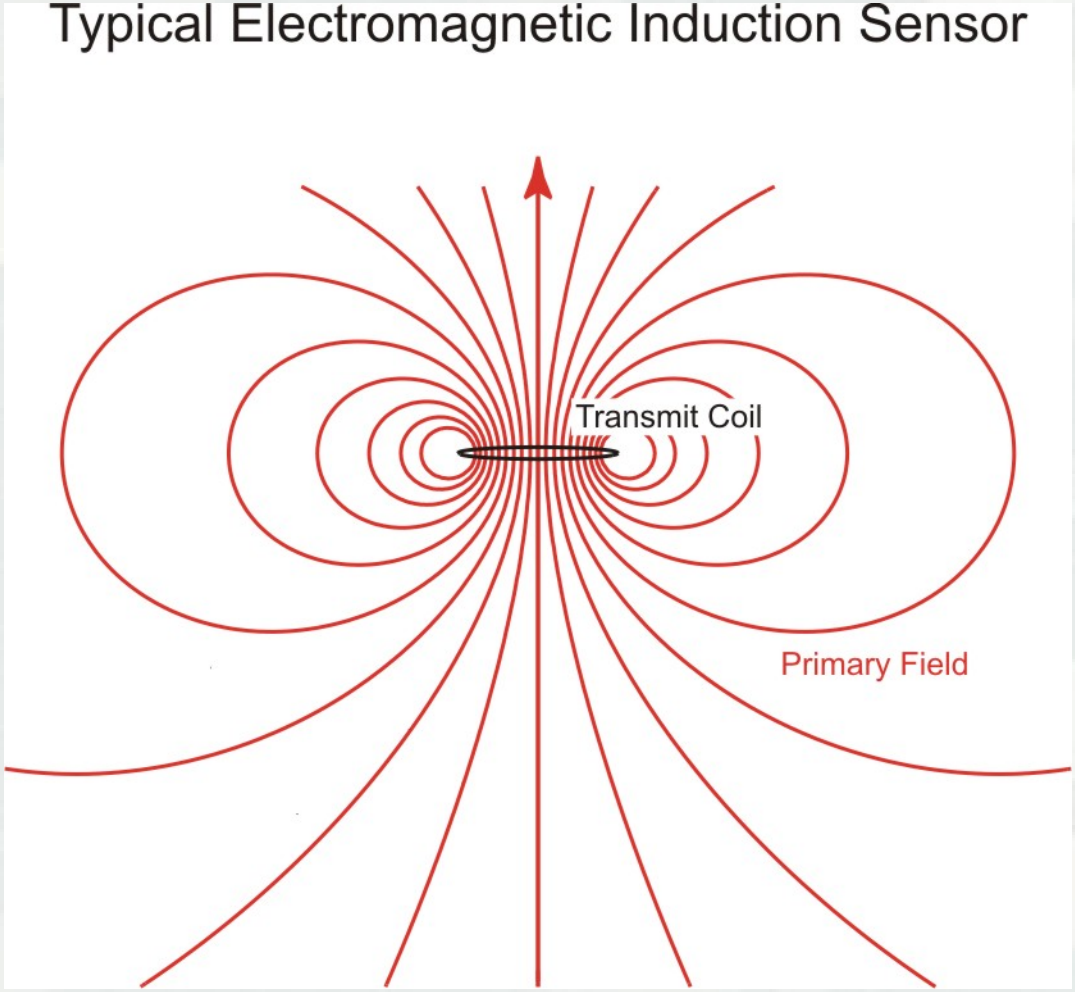
How It Works

Echolocation: a Familiar Analogy



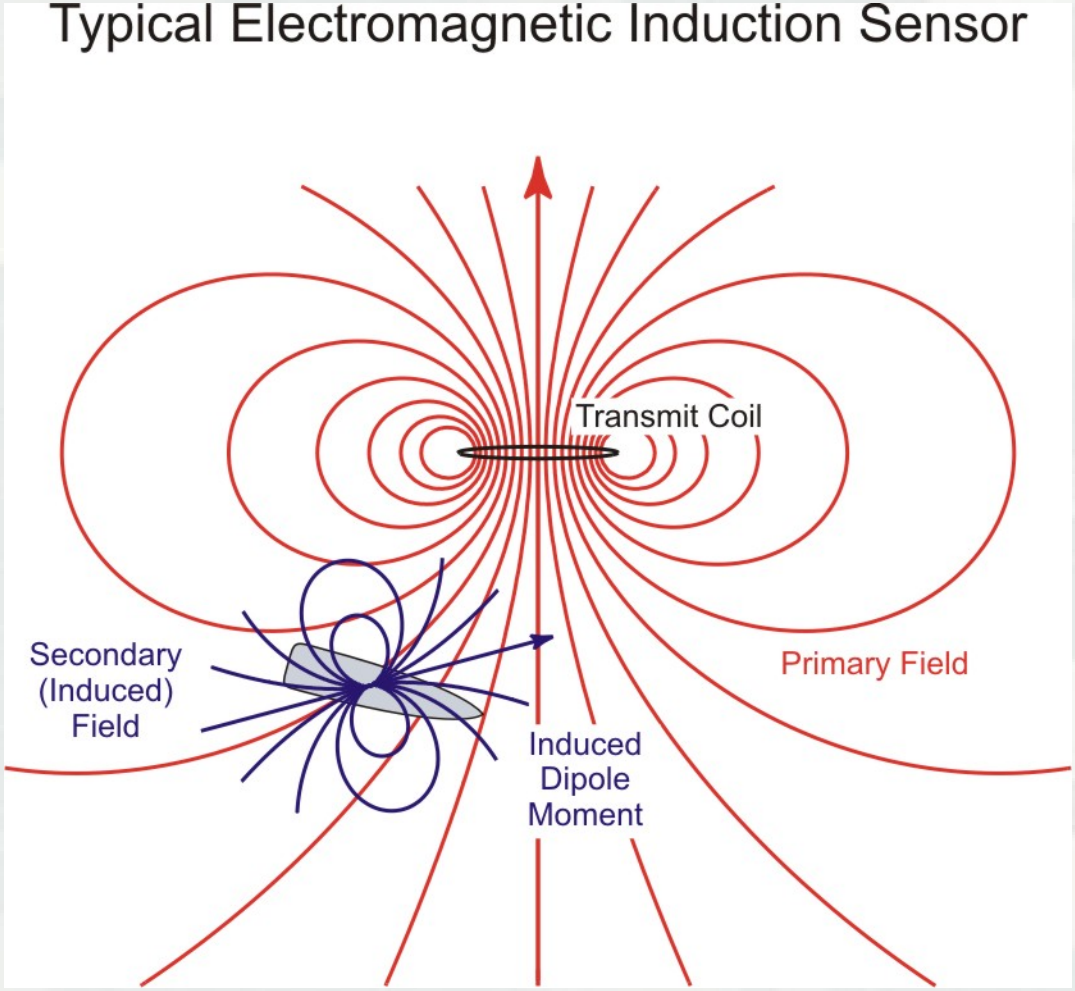
- Acoustic waves…locating objects by reflected sound. Used by dolphins and bats…

Electromagnetic Induction Sensors - Review



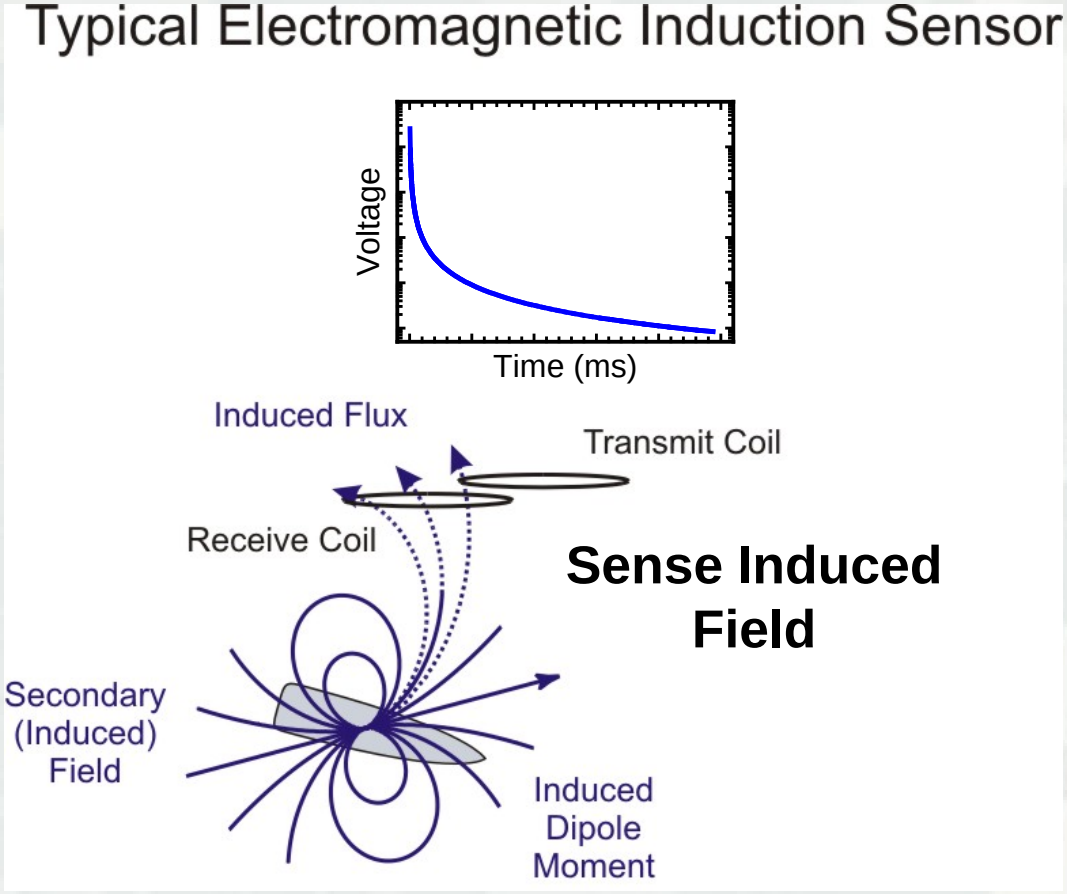
Excitation Pulse

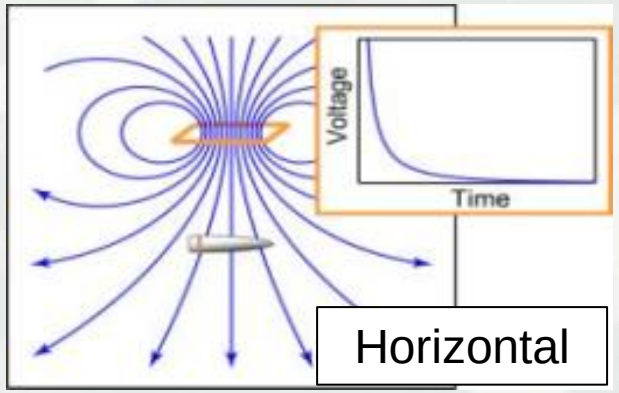
Electromagnetic Induction Sensors (cont.)

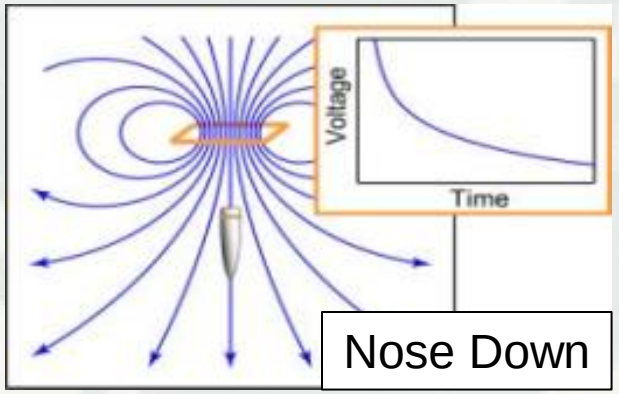


Induced Target Response

Electromagnetic Induction Sensors (cont.)







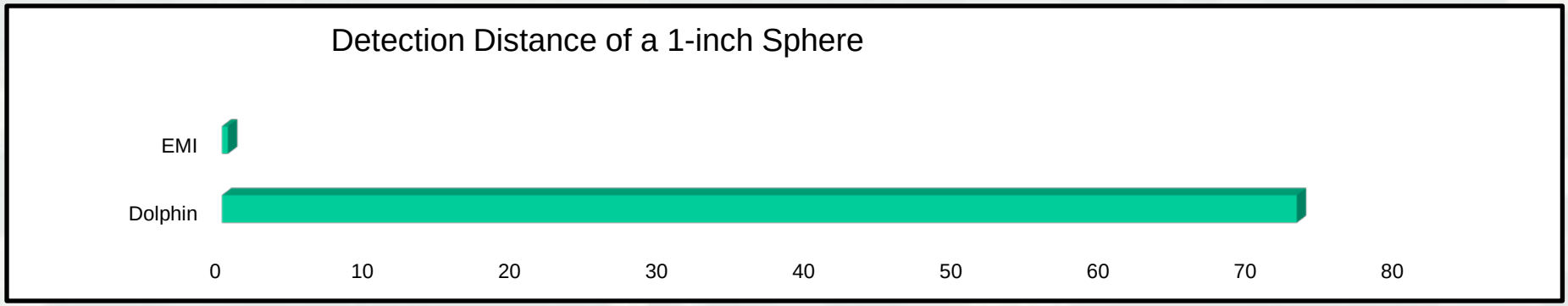
We've seen how the methods are similar, here is one major difference…

Distance: Using echolocation, Dolphins can detect a 2.54cm sphere at 73m!

Your chance to shine…

At what distance can EMI methods detect a 2.54cm metallic sphere?

Answer: 0.4m



EMI response is inversely proportional to the Distance^6 (sensor to object).

The sensors have to be very close to the object in order to detect and characterize buried objects!

A Term You Need To Know:
Polarizability

- A set of values that fully describe the decay of electromagnetic fields that have been induced in an object by an external EM source, after the external EM source is removed. Polarizability values exist <u>for each of the object's three principal axes</u>
- They are used here:
  - The EMI Dipole Model

$$\mathbf{V}(t) = \mu_0 n_R n_T I_0 \mathbf{C}_R \cdot \mathbf{C}_T \mathbf{B}(t)$$

The EM Signal We Measure

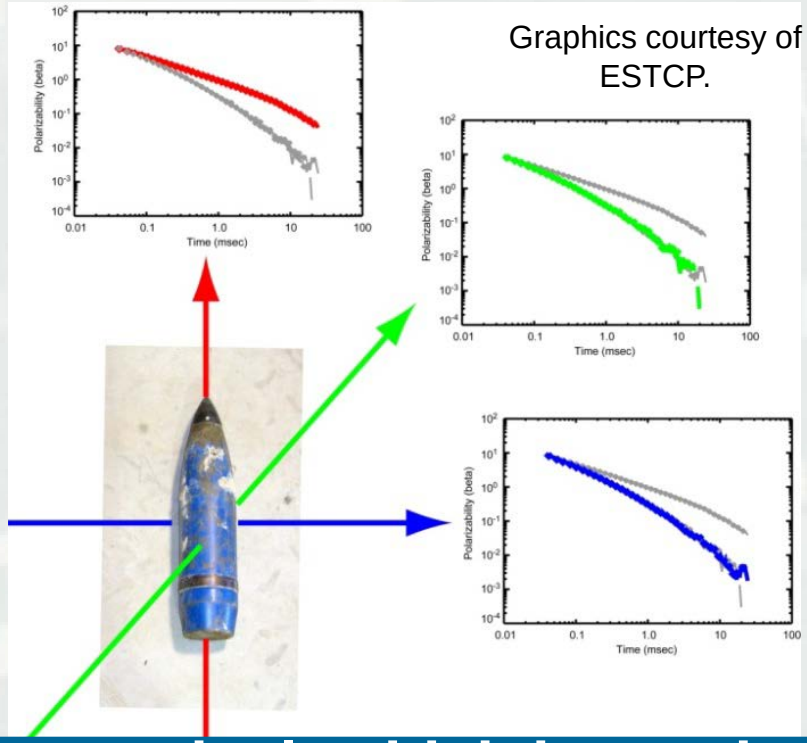
Sensor properties & Geometry of the sensor wrt target

Target properties (polarizabilities)

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Principal Axis Responses

- Normalized response (polarizability) for excitation in object's principal axis directions are the fundamental EMI attributes
- UXO items are symmetrical, so two of the principal axis responses are the same
- Irregular clutter items have three different principal axis responses



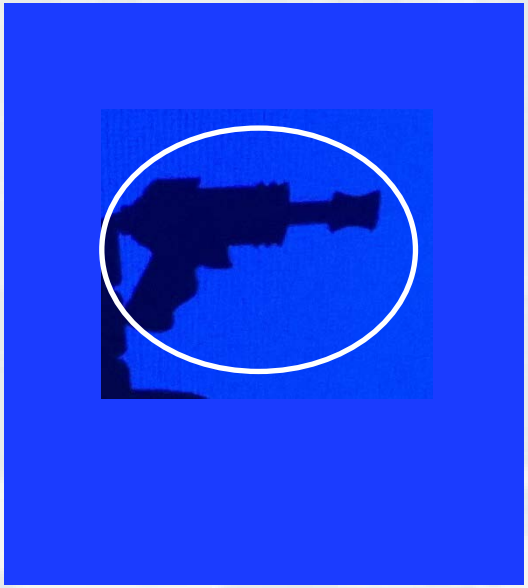
Graphics courtesy of ESTCP.

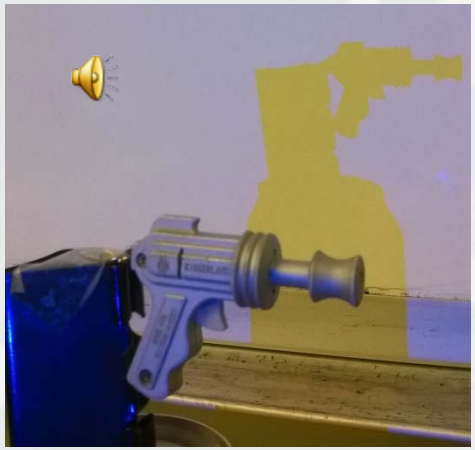
Key Point **Munitions are symmetrical, which is used to identify them**

A Simple Analogy

Name That Object…



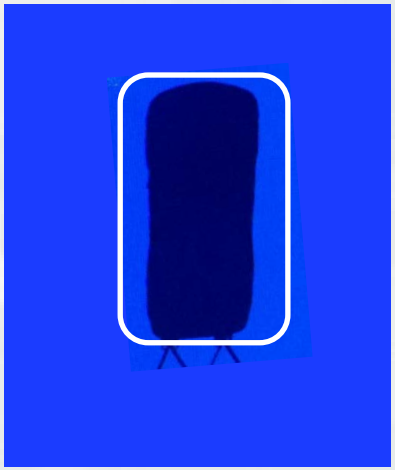




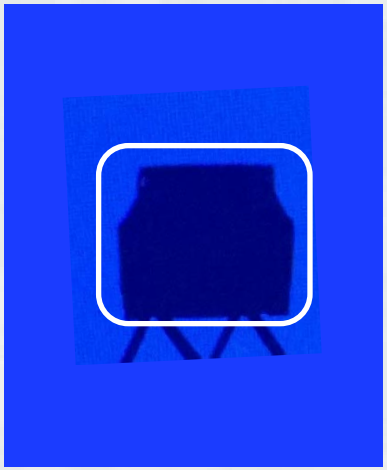


A Simple Analogy

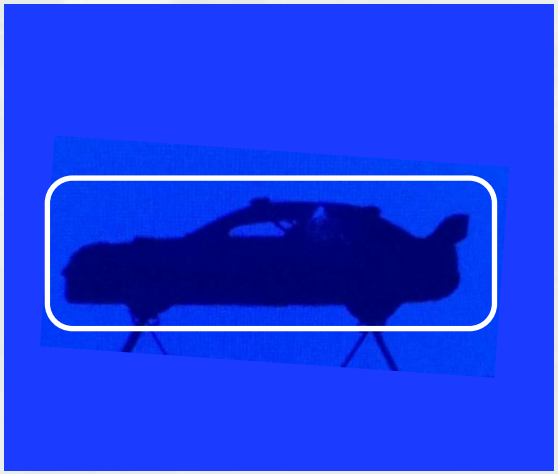
Name That Object…



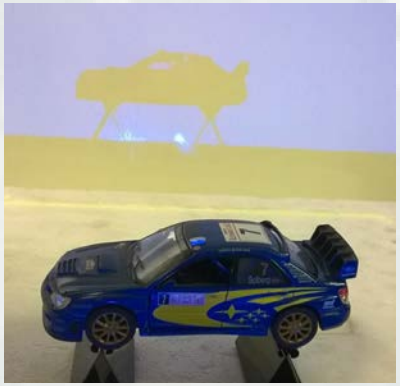
Top View
(compare to “Top View Polarizability”)



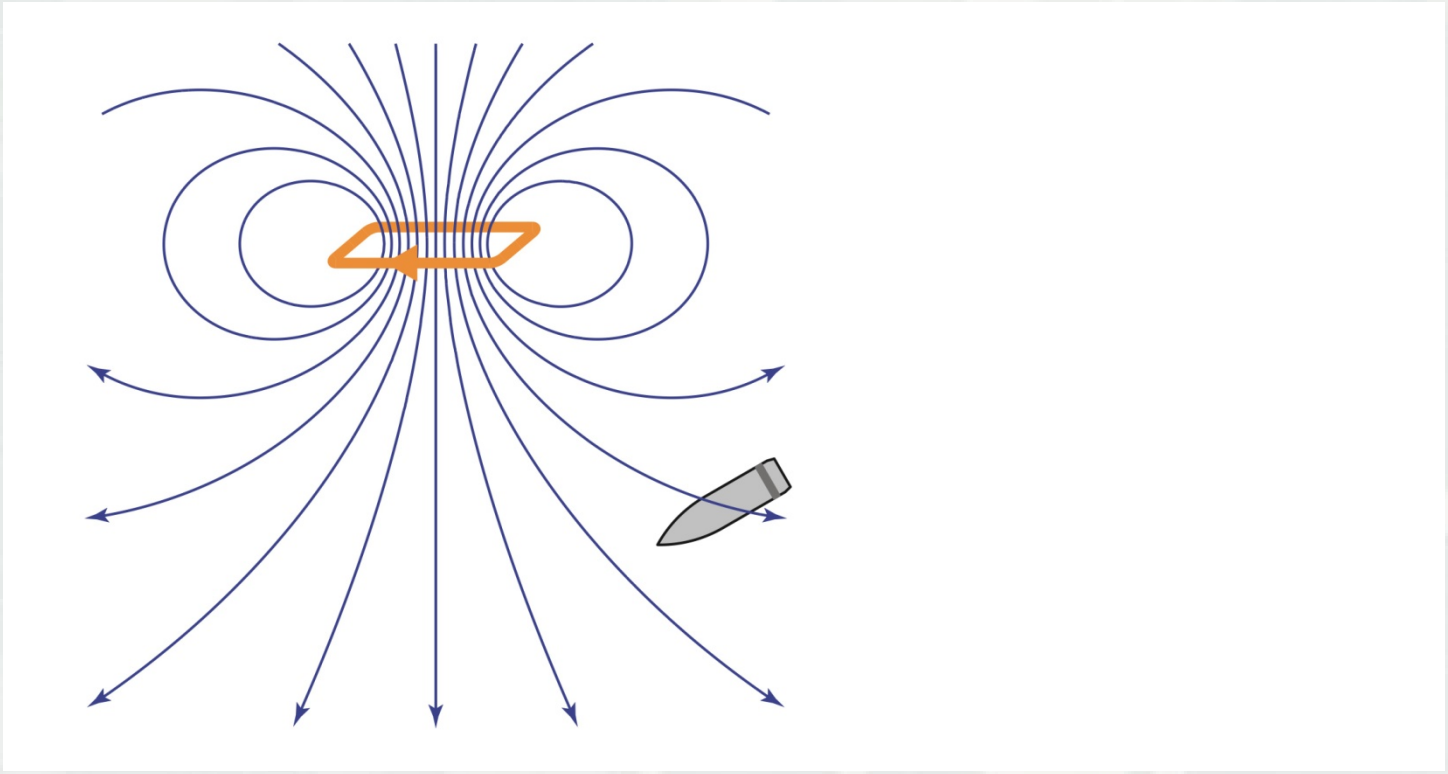
Front View
(“Front View Polarizability”)



Side View
(“Side View Polarizability”)

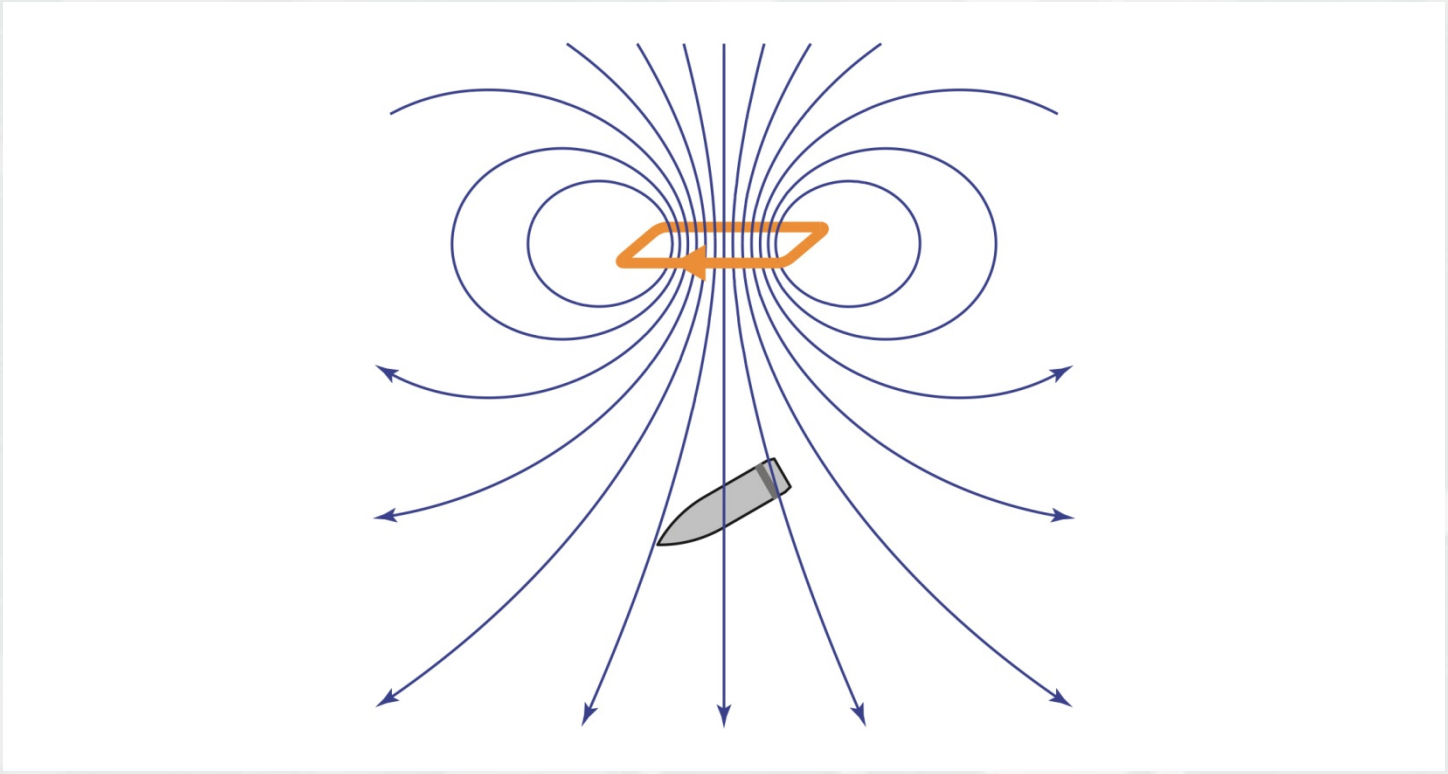


Multiple Measurements are Required to Completely Characterize a Target with a Single-Axis Sensor (cont.)



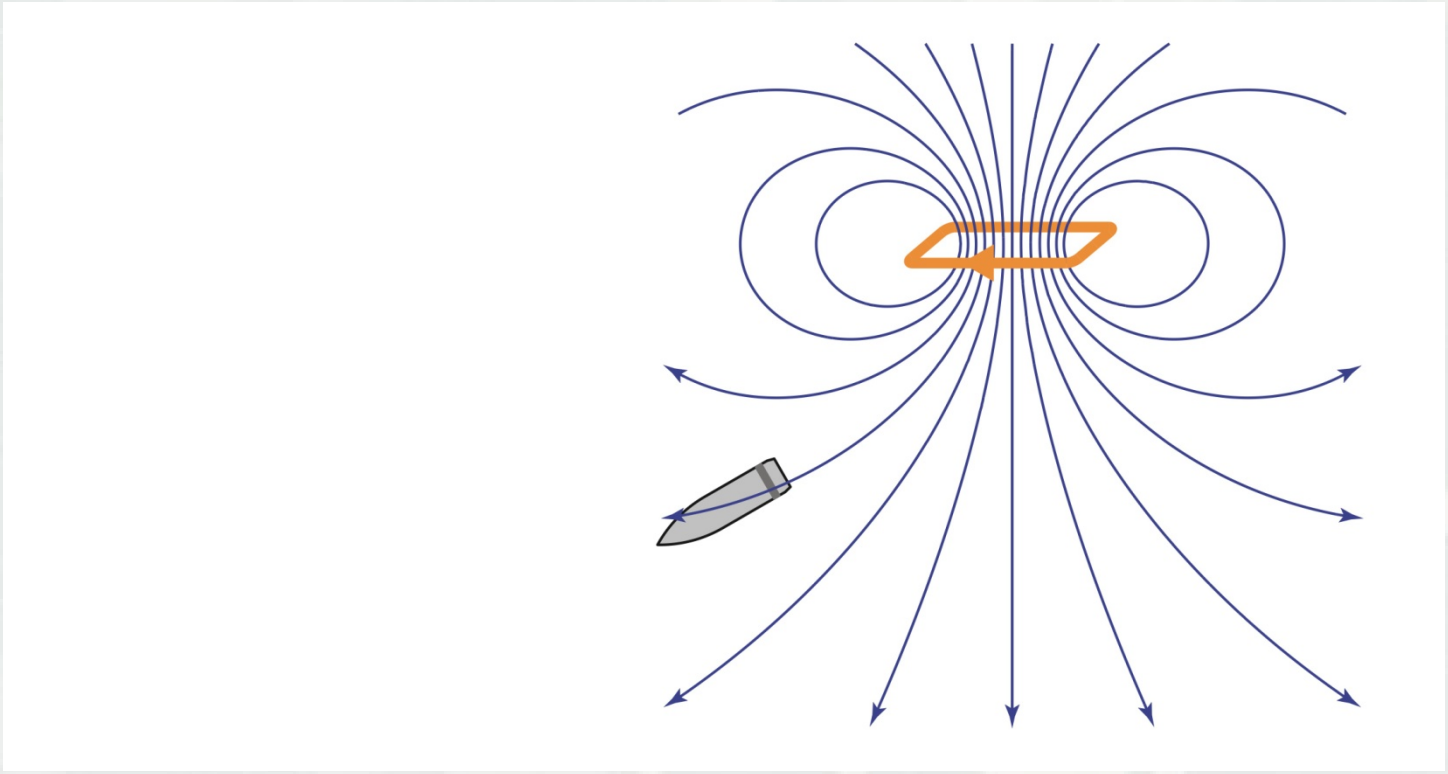
At each position the field lines only intersect the target in one direction

Multiple Measurements are Required to Completely Characterize a Target with a Single-Axis Sensor (cont.)



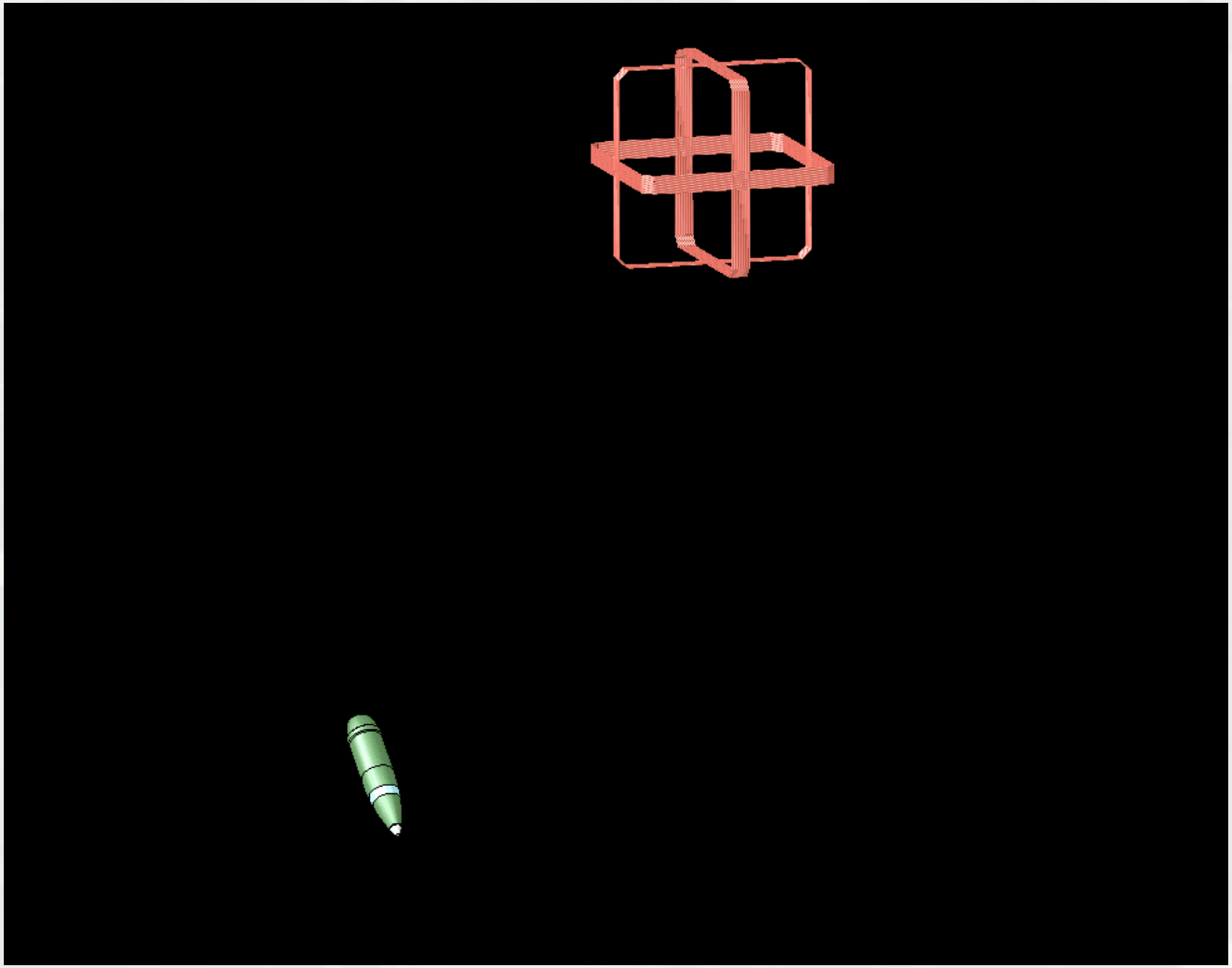
At each position the field lines only intersect the target in one direction

Multiple Measurements are Required to Completely Characterize a Target with a Single-Axis Sensor (cont.)



At each position the field lines only intersect the target in one direction

The Trick Is Illuminating Each Axis With a Tx Pulse



This is what Advanced EMI Sensors look like

- Multiple coils measure the complete response of buried items (spatially and temporally)



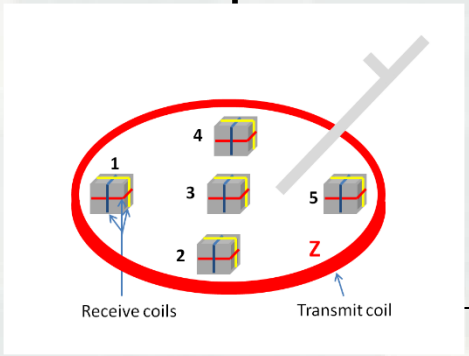
Person-portable

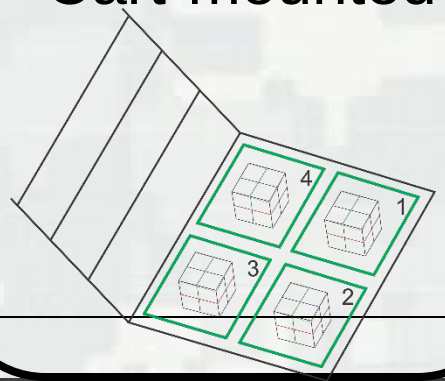


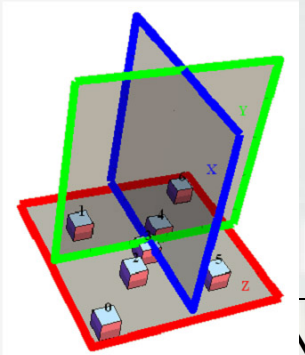
Cart-mounted



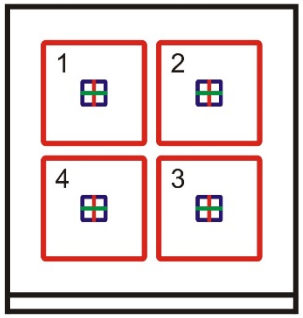
Vehicle-towed







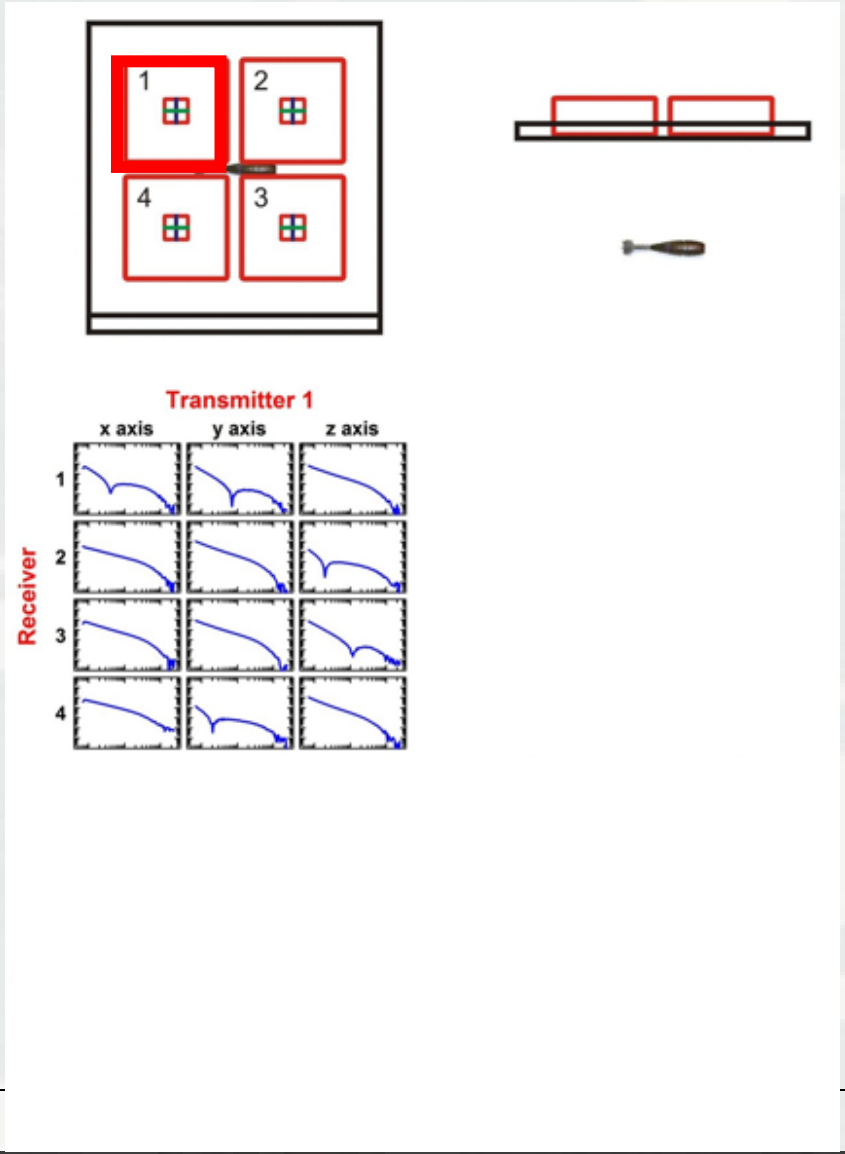
Advanced EMI Sensors: designed for UXO classification



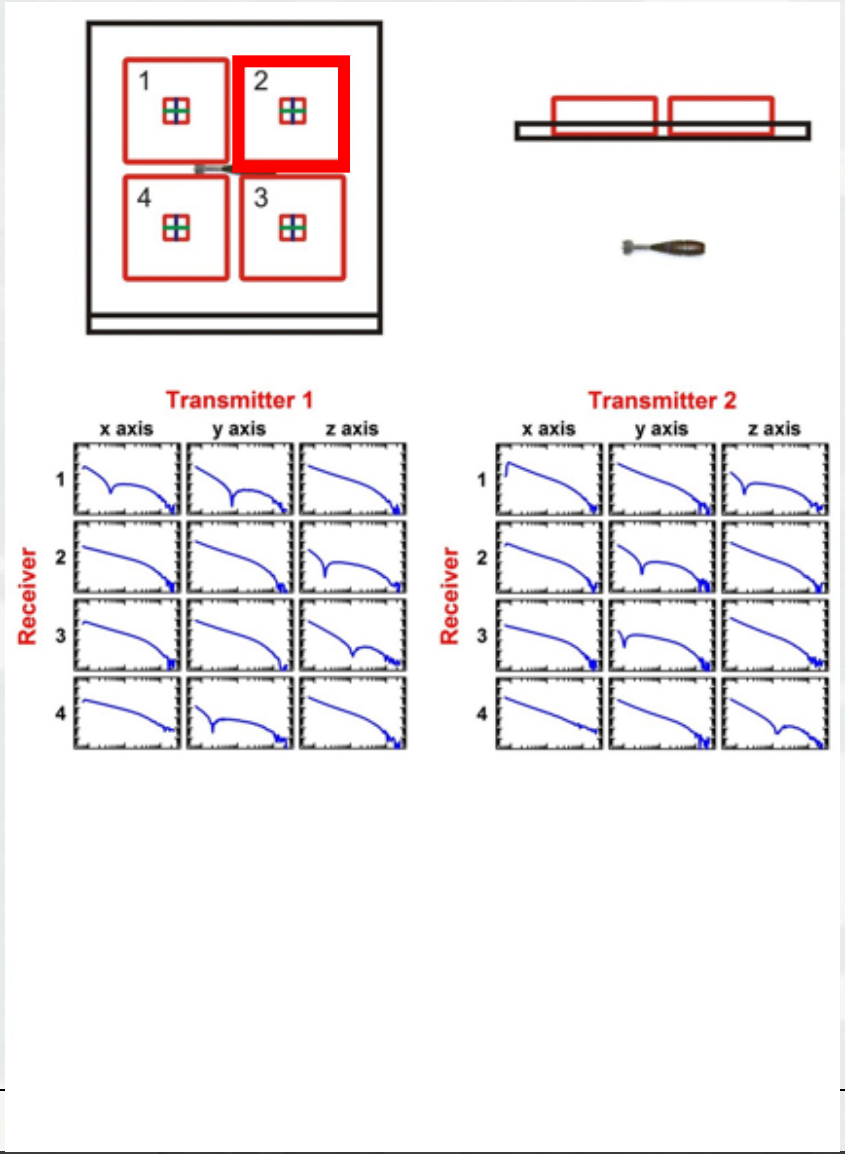


Multiple transmitters and receivers are used to fully ‘light up’ or illuminate the object

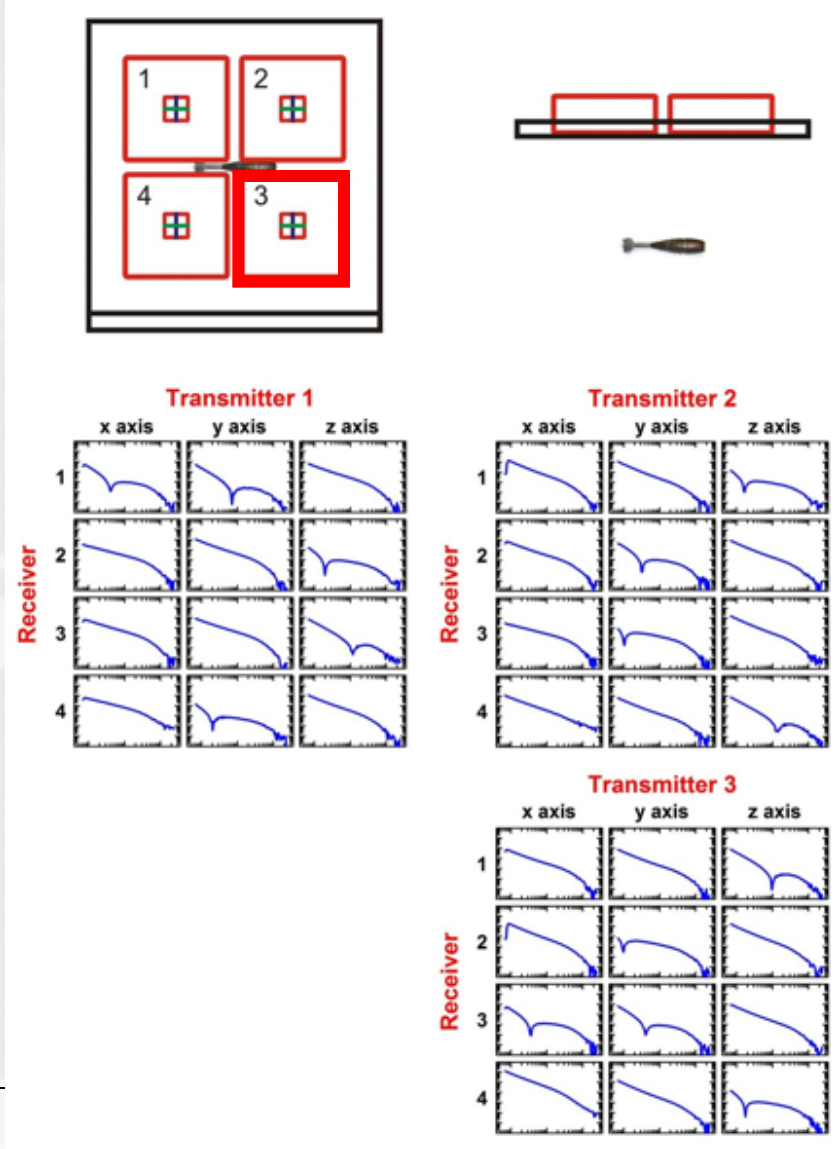
Measured data are affected by burial depth and object orientation



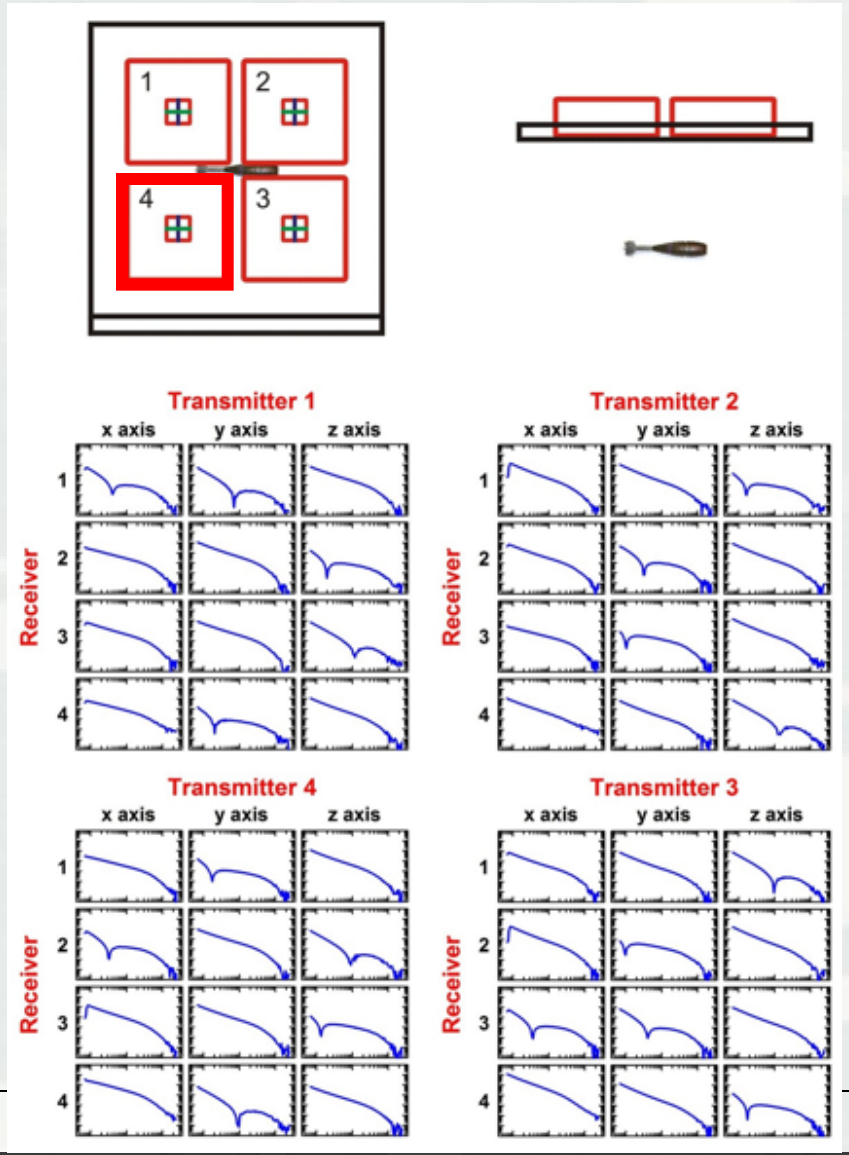
Measured data are affected by burial depth and object orientation



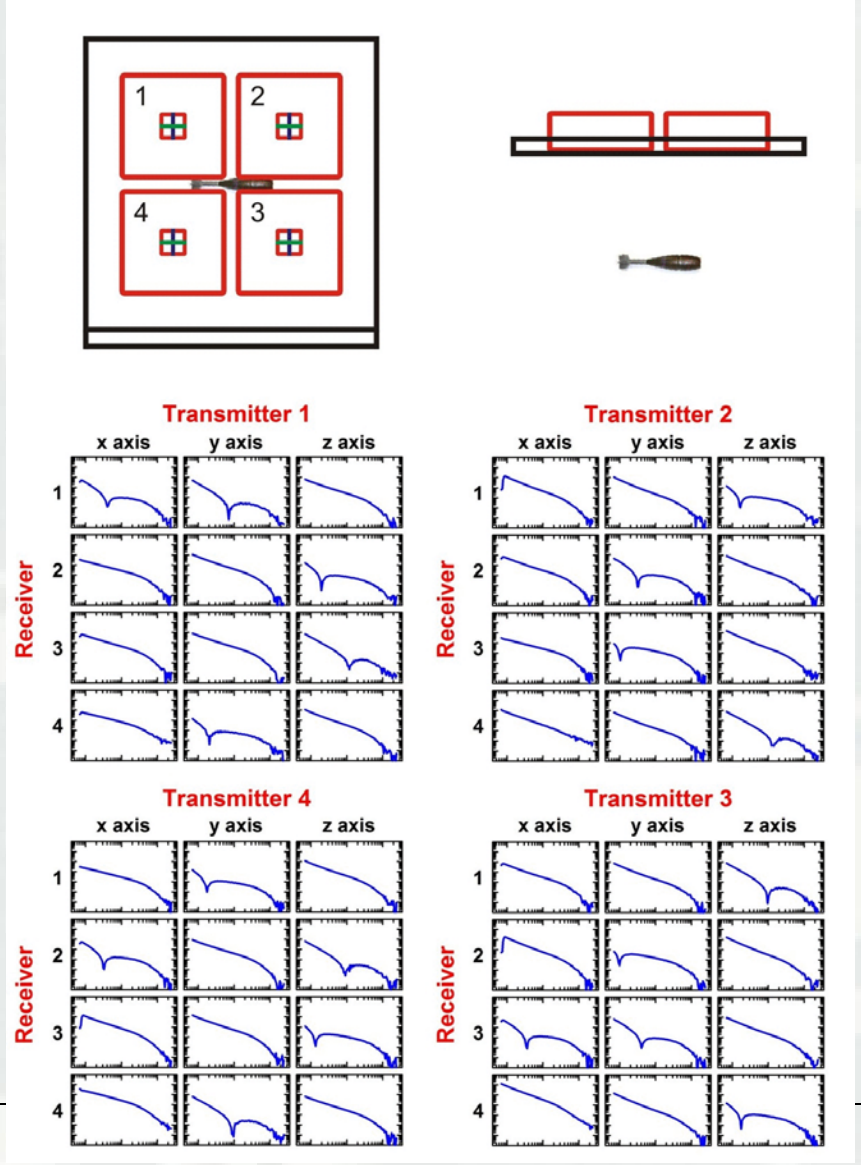
Measured data are affected by burial depth and object orientation



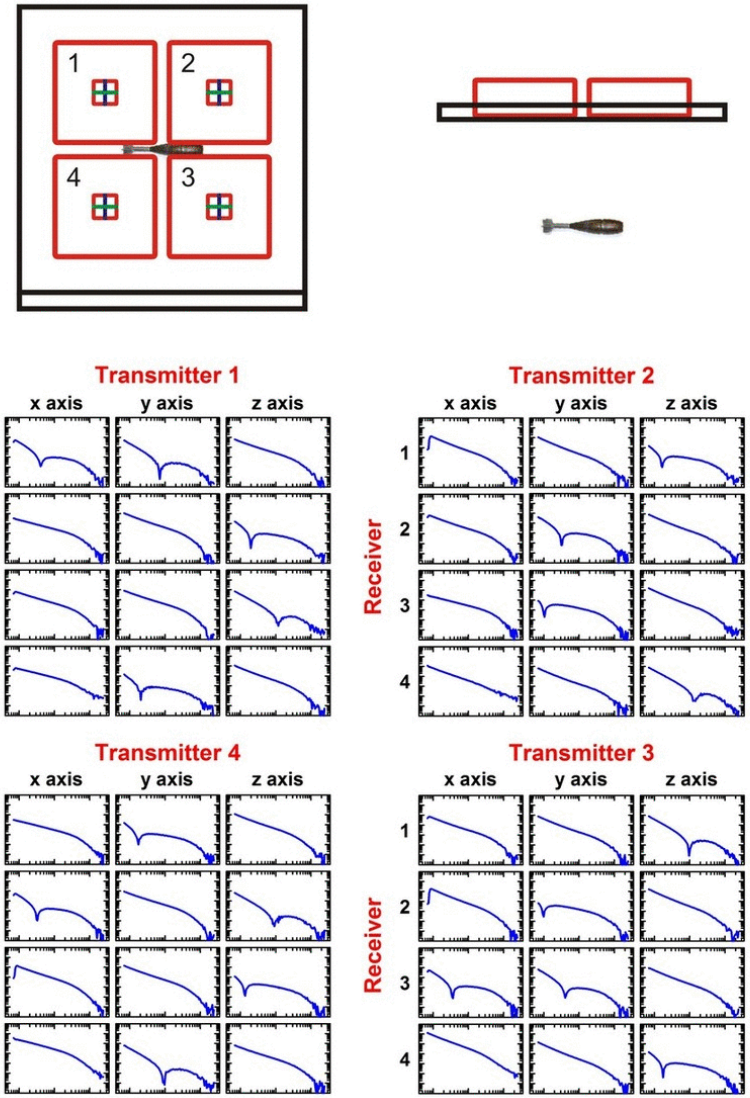
Measured data are affected by burial depth and object orientation

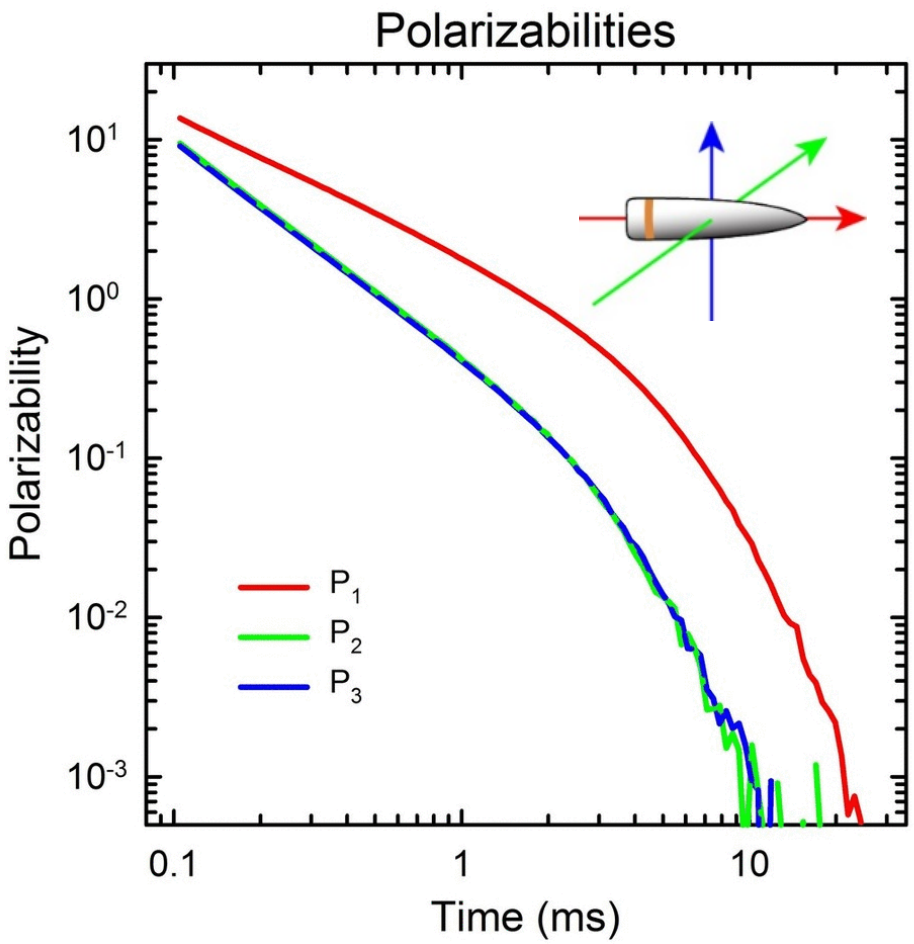


Measured data are affected by burial depth and object orientation



Polarizabilities do not change with burial depth or orientation





Advanced Classification Is Inherently A Three-Step Process

1. Collect Field Data
   - Specialized, classification-specific instruments
2. Get fingerprint for each detected anomaly
   - Field Data
   - Specialized Software
   - Trained Analyst
3. Assess if the fingerprint is something we need to be concerned about
   - Polarizabilities
   - Library fingerprints of things I'm concerned about
   - Specialized Software
   - Trained Analyst

How Do We Get Those Fingerprints?

- Another Term you need to know:

  ‘Geophyiscal Inversion’

  - a.k.a. Backward model!

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This Is A Forward Model

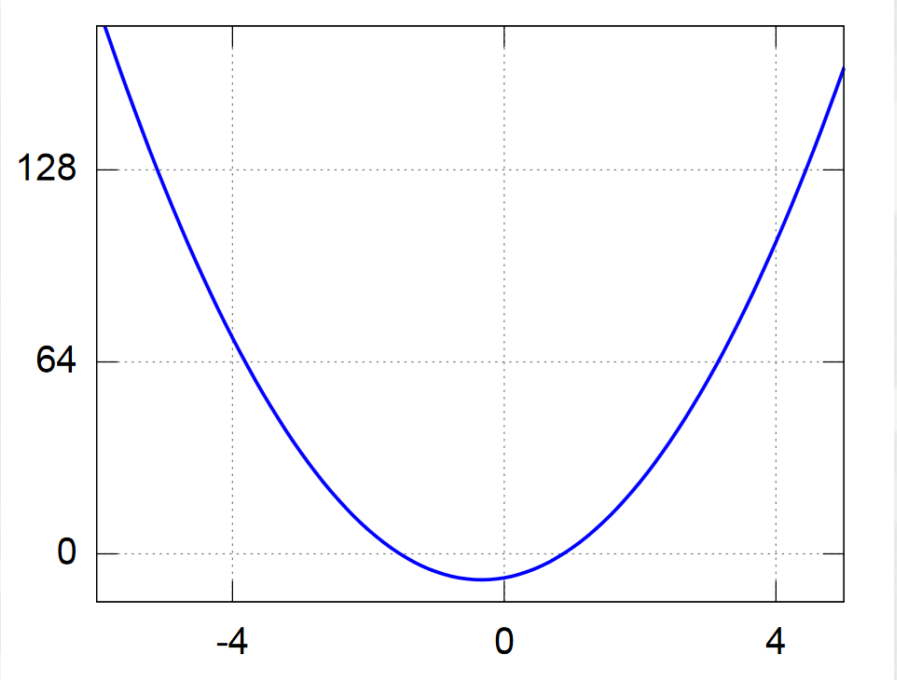
Given this:

$y=6x^2+4x-8$

For each value of x we can calculate y

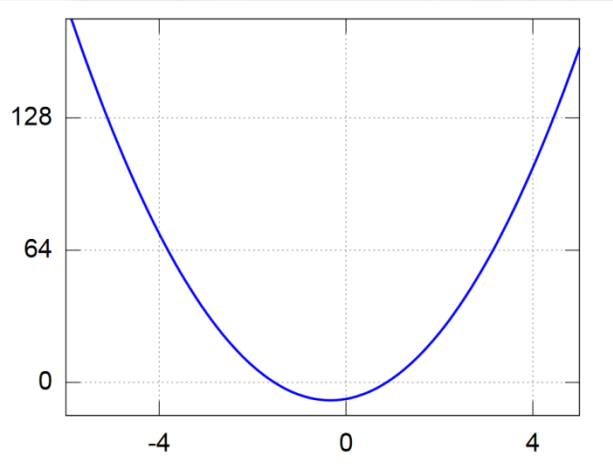
x	y
-5	138
-4.5	111.5
-4	88
-3.5	67.5
-3	50
-2.5	35.5
-2	24
-1.5	15.5
-1	10
-0.5	7.5
0	8
0.5	11.5
1	18
1.5	27.5
2	40
2.5	55.5
3	74
3.5	95.5
4	120
4.5	147.5
5	178

And we can graph it

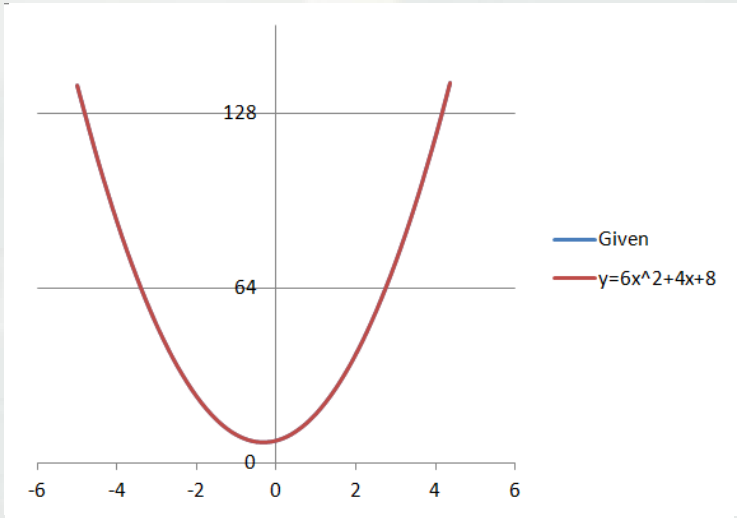


This Is A Backward Model (aka Inversion)

Given this:



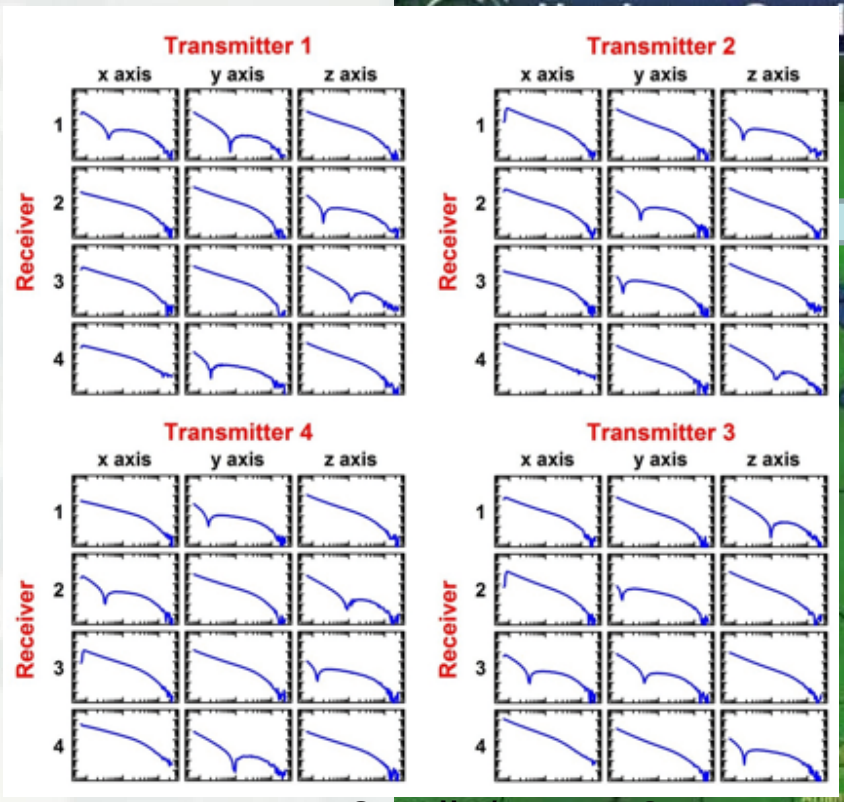
We can make educated guesses on the formula…



Until we get it correct

From Field Data to Predictions

TEMTADS Field Data



4 Tx × 4 Rx × 3 coils/Rx × 50 channels/Rx coil = 2,400 measurements per anomaly

From Field Data to Predictions

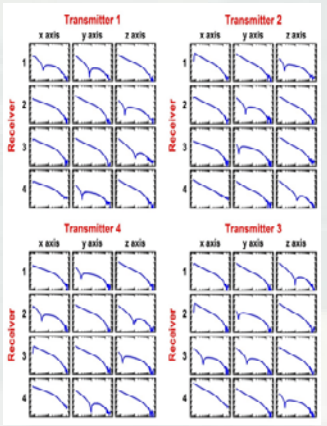
The software sequences through geometry & polarizabilities and calculates theoretical responses

EMI response model

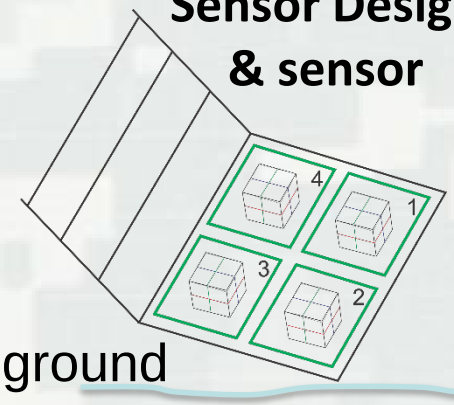
$$V(t) = \mu_0 n_R n_T I_0 C_R C_T P(t)$$

Field Data



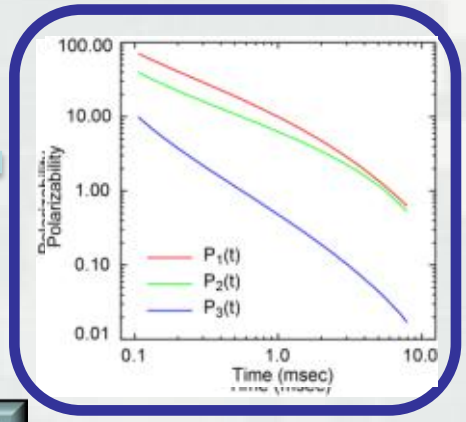


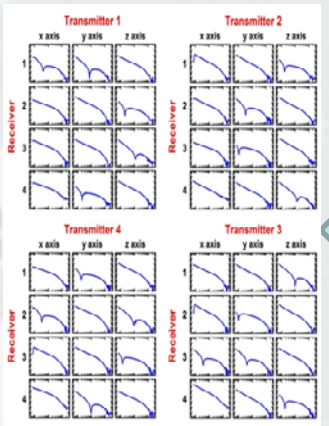
Sensor Design & sensor



ground

Polarizabilities





Software stops when theoretical response matches TEMTADS data

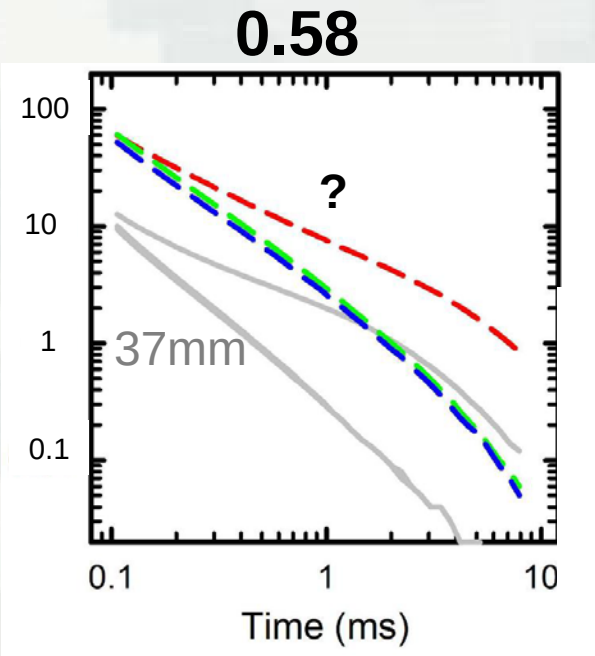
(theoretical response)



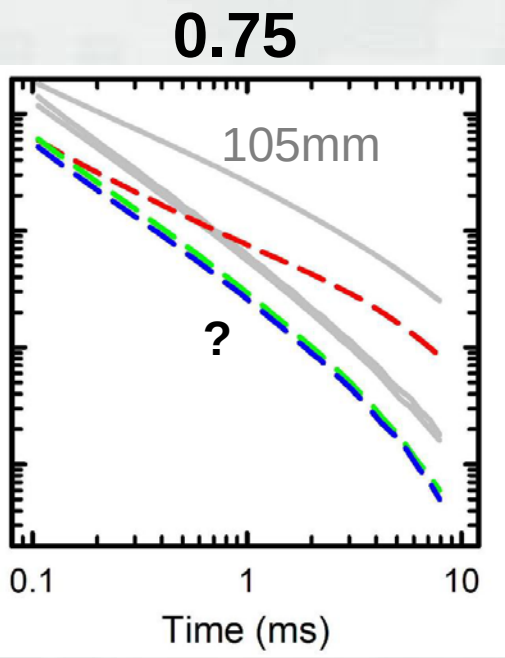
Mystery Object Location (x,y,z) & orientation (θ,ϕ,φ)

Once We Have The Fingerprint…We Classify!

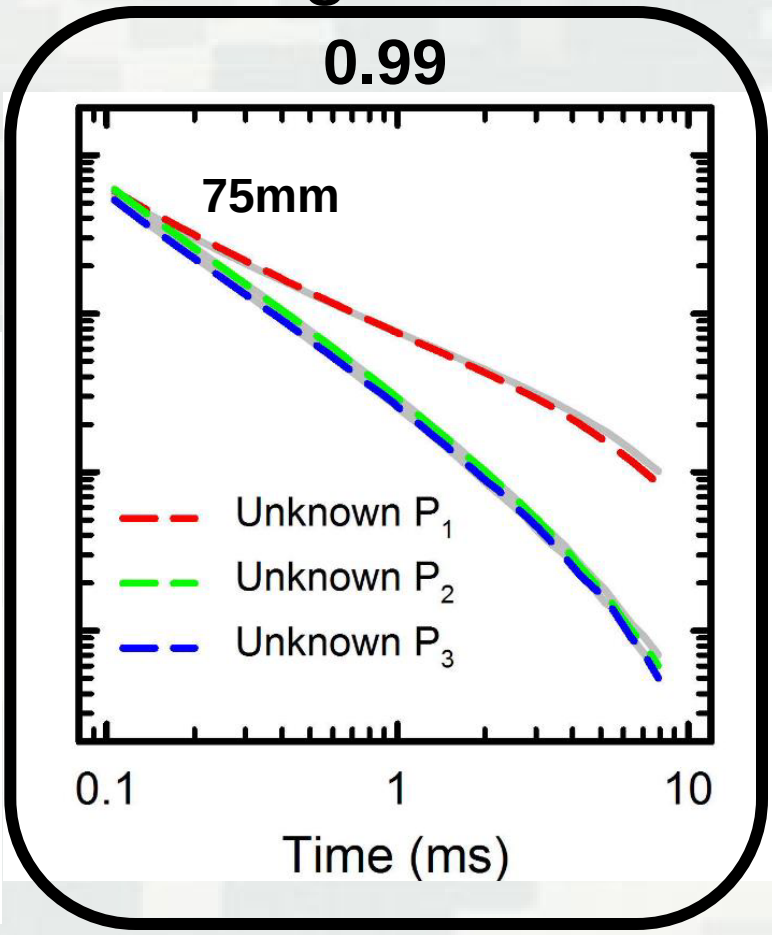
- Classification via template matching



…too large for 37mm



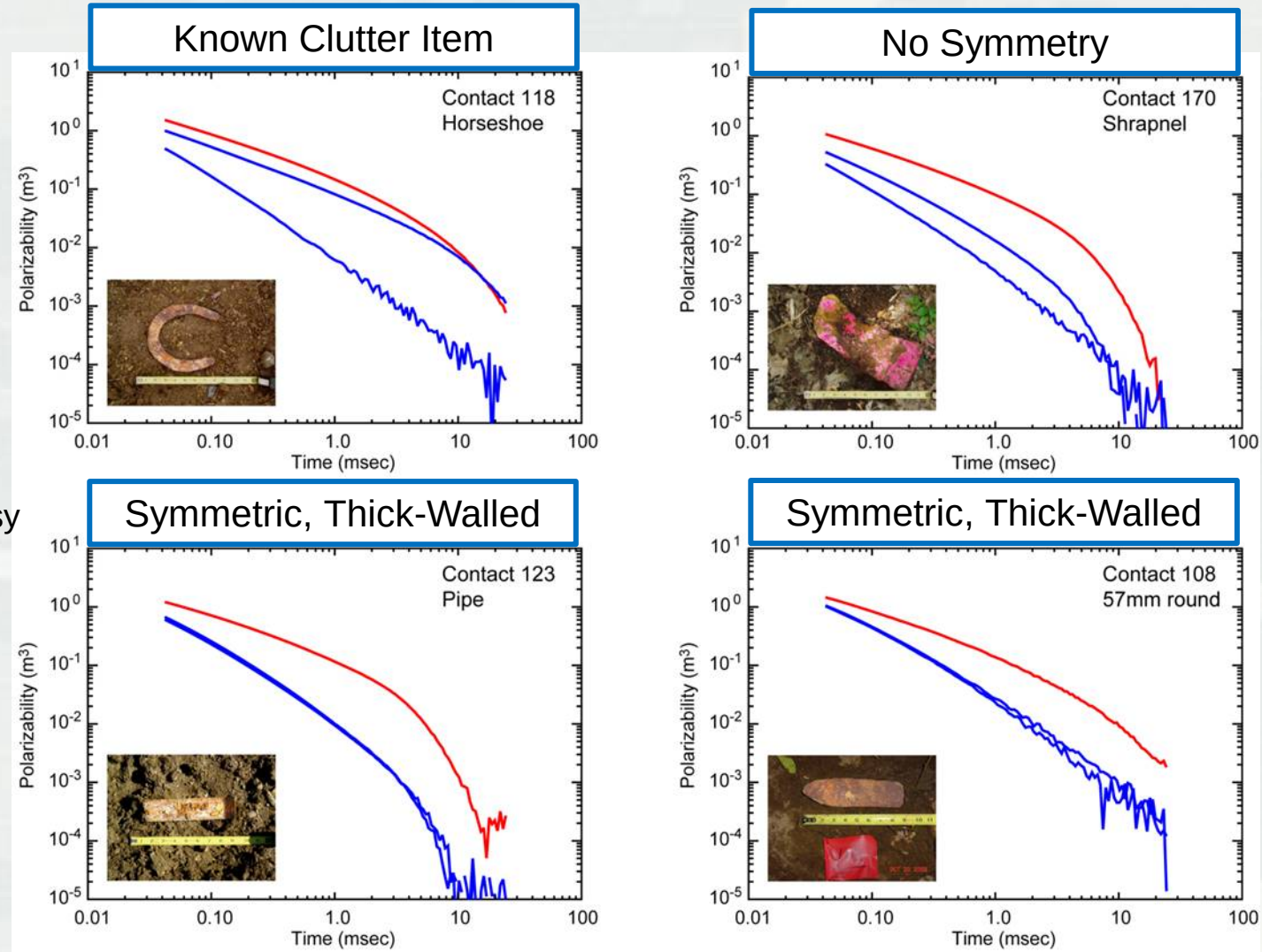
…too small for 105mm



…just right. MATCH

Polarizability Examples “EMI Fingerprints”

Graphics courtesy of ESTCP.



Polarizabilities completely specify the target's EMI response characteristics

Object Property	Polarizability Property
Cylindrical Shape	Axial Symmetry
Wall Thickness	Decay Rate
Physical Size	Magnitude

What If…

- Someone thinks there's a UXO out there that's not in my library?
  - First: make sure it makes sense
  - Then
    - Add it if you can
    - Look for obvious traits

…Big, Ugly & Scary
(i.e. large, axial symmetry and thick walled)

What If…

- There are groups of things with the same fingerprint that I don't know about?

  We call this: Analyze for clusters

  How it works:

  1- Select one of the inversion solutions to be the basis of the analysis

  2- Rack & Stack every other inversion solution

  3- Compare each of (2) to (1), one by one

  If (2) similar to (1) then add to the (1) group

  This is just like library matching, except the fingerprint in (1) is "the library" for each run

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Cluster Analysis Basics

- Some Cluster Analysis Basics
  - Need to select a match metric
    - 0.95 is common
  - Decide on a minimum number of items that defines "group"
    - Have seen numbers such as 3, 4, 5, 10
  - Only use inversion solutions that pass all QC
  - Have an expert on your team!

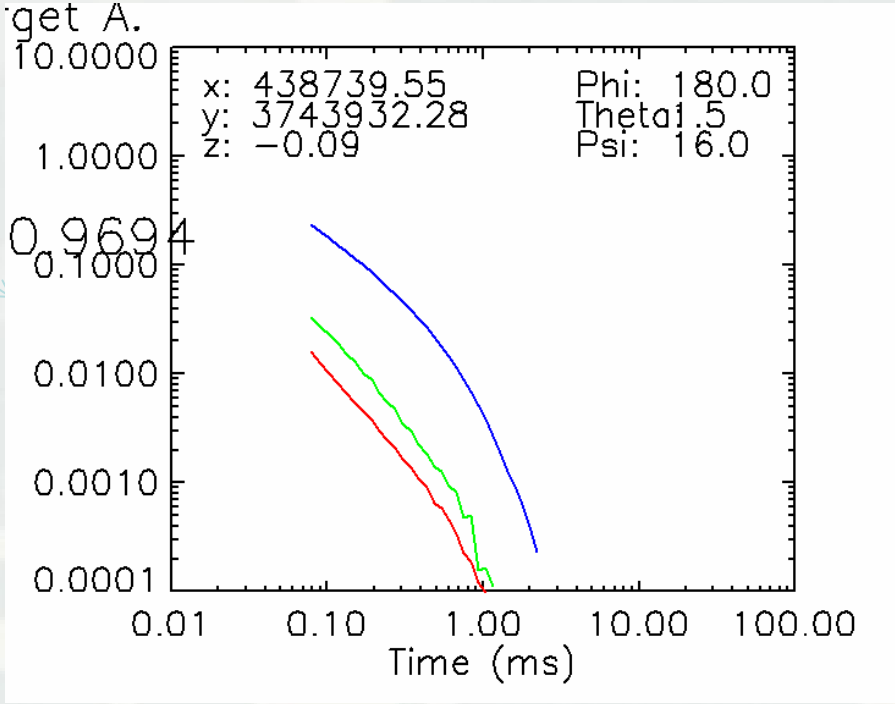
Let's see how this works using 0.95 match metric

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Analyze For Clusters Example

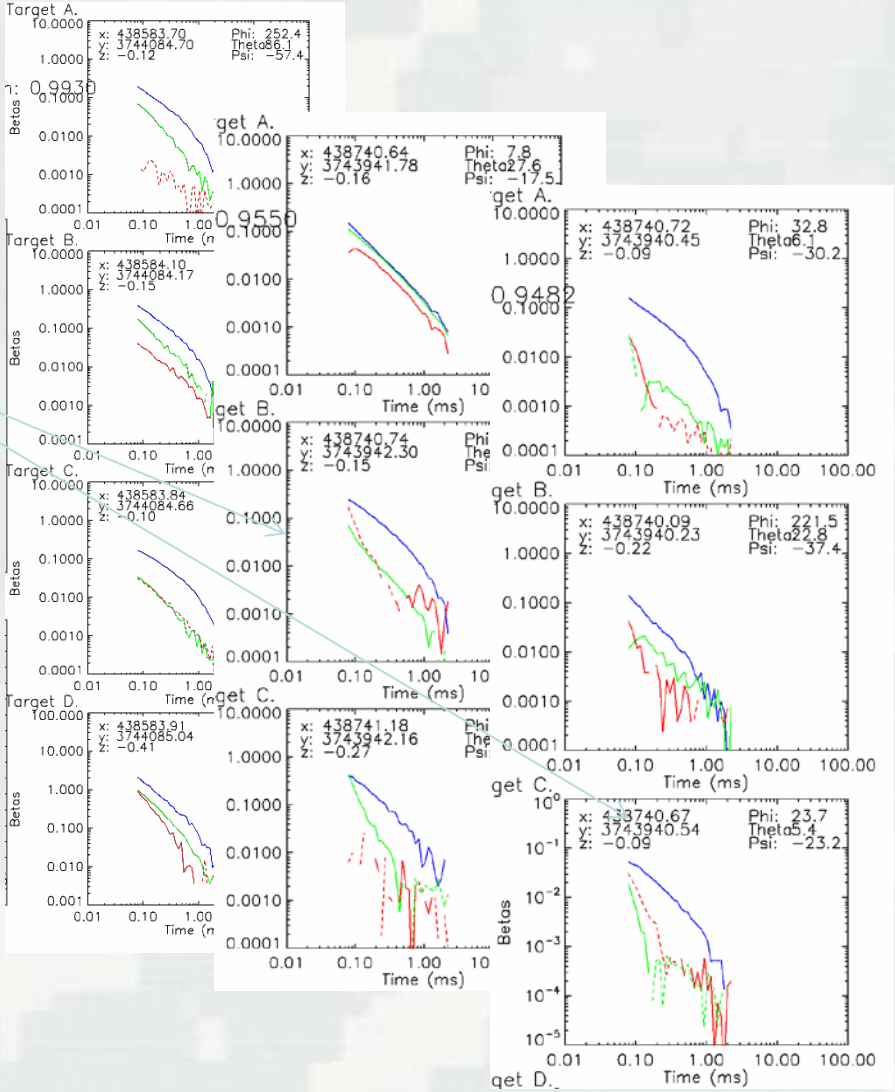


Set this as our “Library”



Analyze For Clusters Example



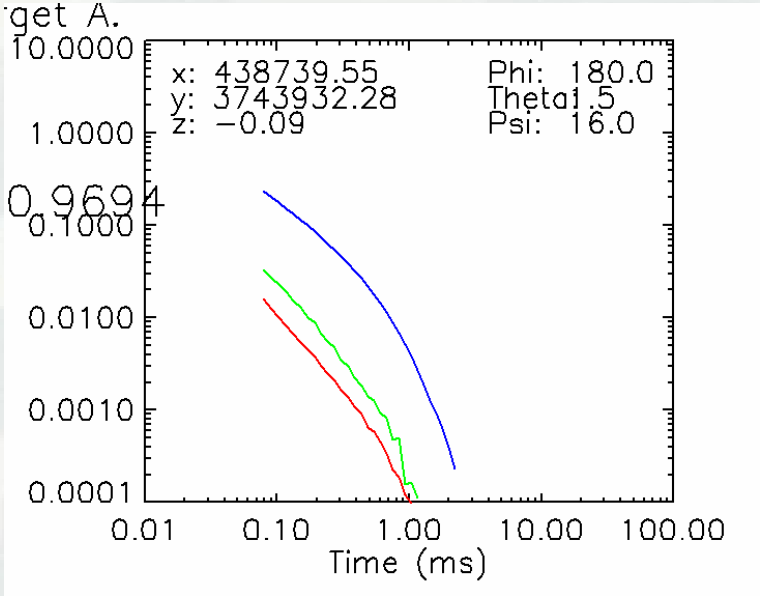


Rack & Stack'em…

Analyze For Clusters Example

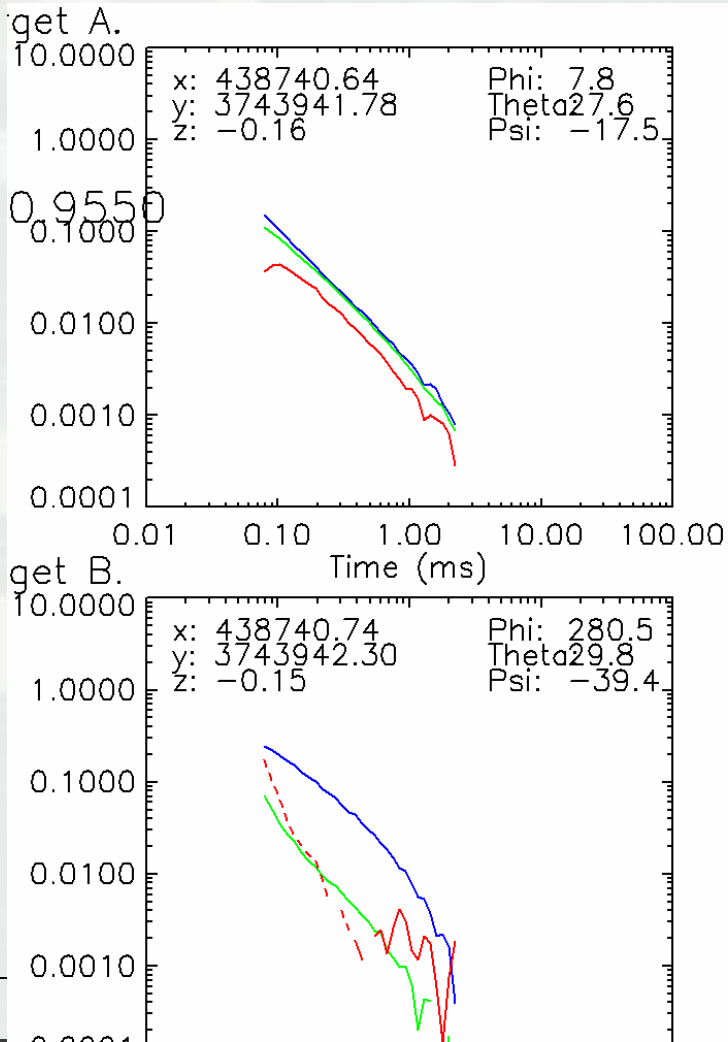
Match Better Than 0.95?

The basis of comparison signature aka “The Library”



0.34

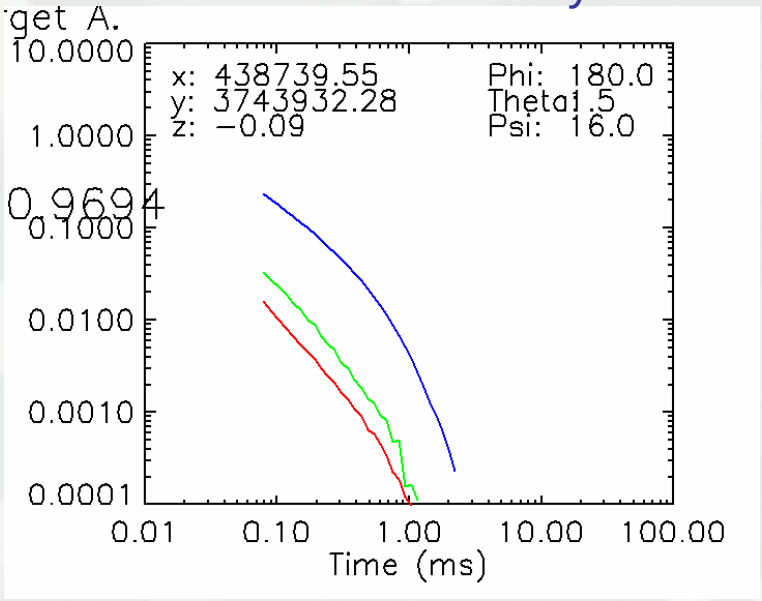
The Stack



Analyze For Clusters Example

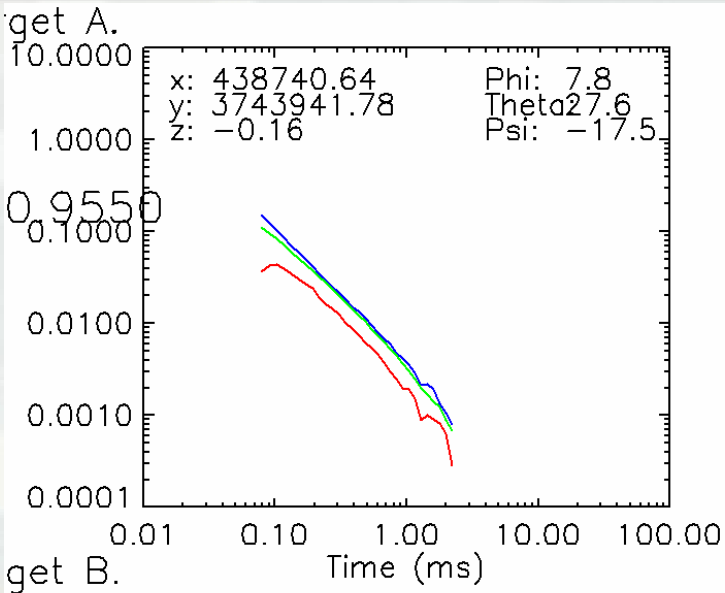
Match Better Than 0.95?

The basis of comparison signature
aka “The Library”

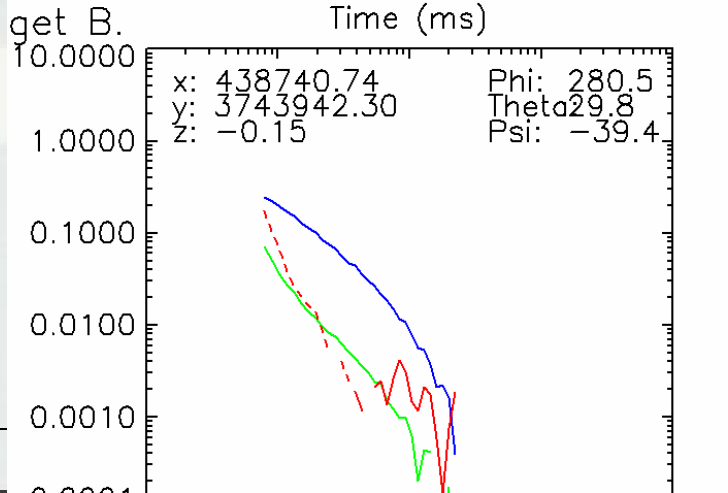


0.9694

0.34



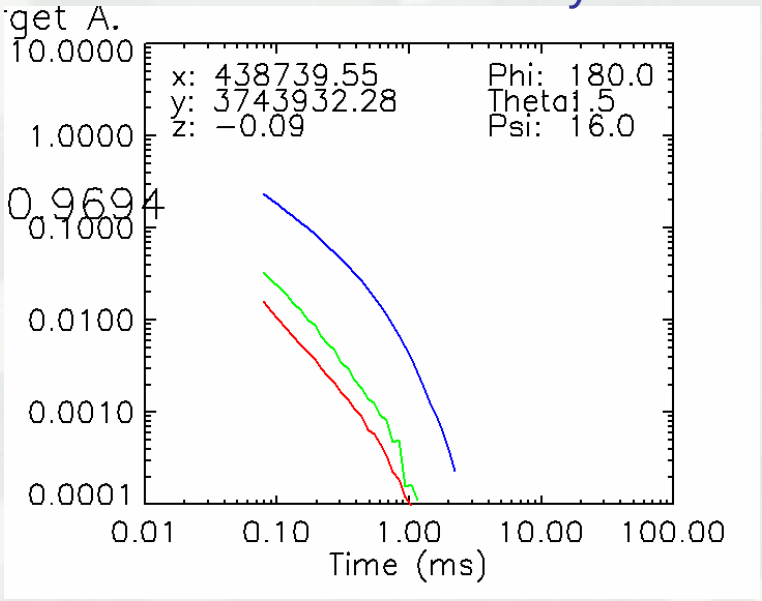
0.9550



Analyze For Clusters Example

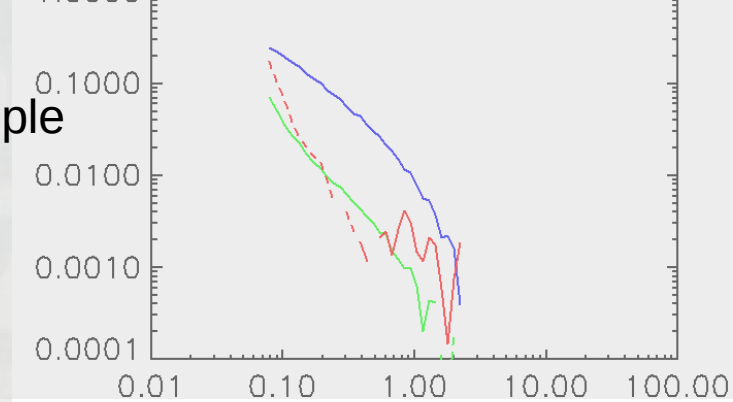
Match Better Than 0.95?

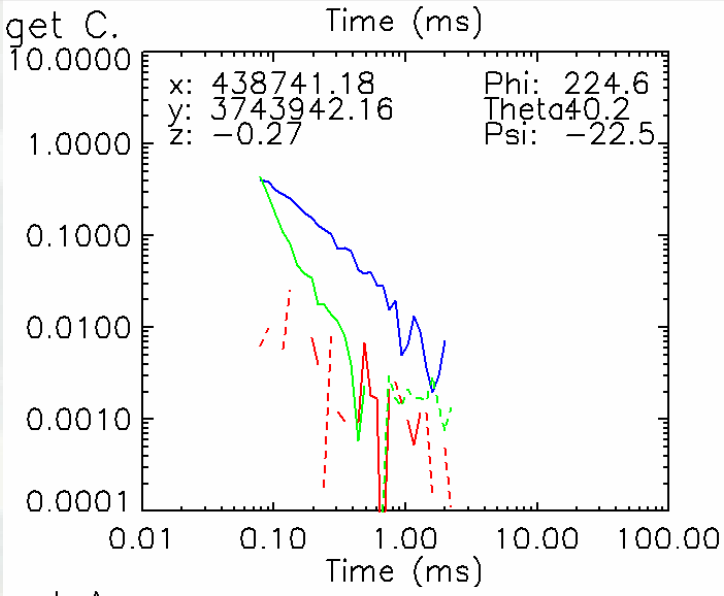
The basis of comparison signature
aka “The Library”

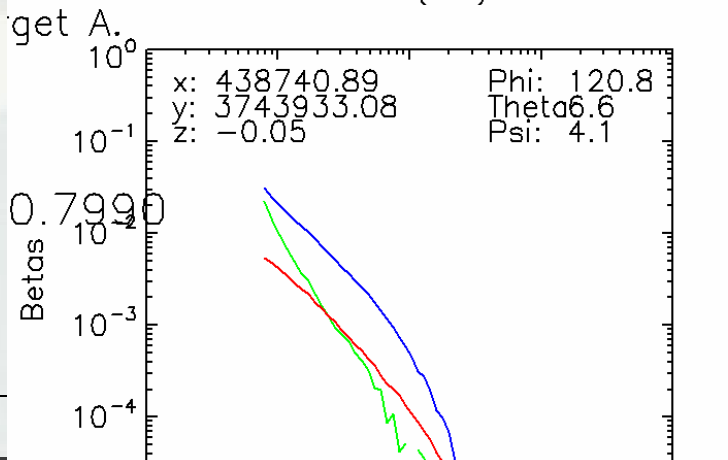


0.9694

0.12





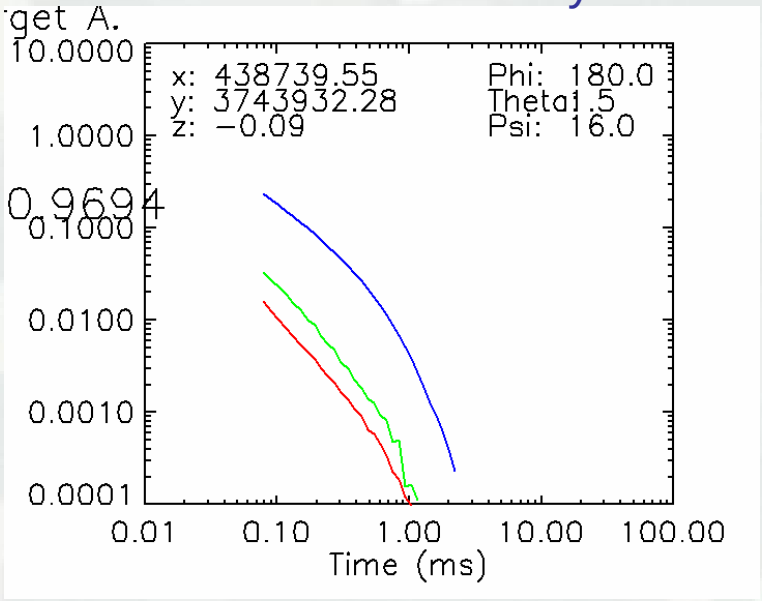


0.7990

Analyze For Clusters Example

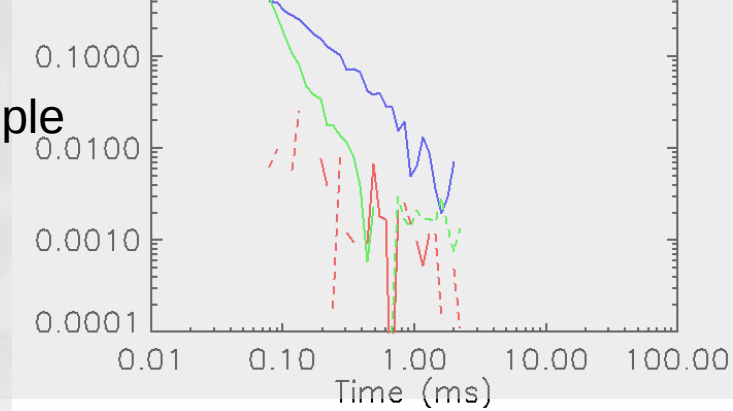
Match Better Than 0.95?

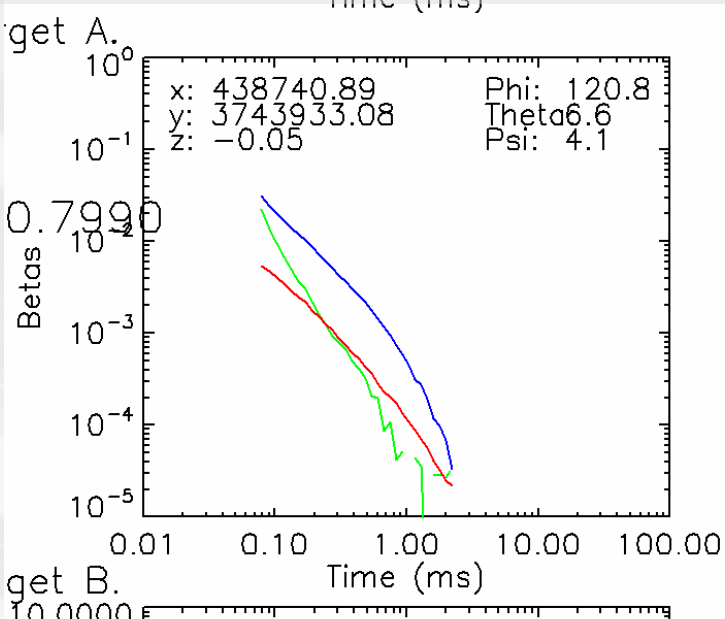
The basis of comparison signature
aka “The Library”



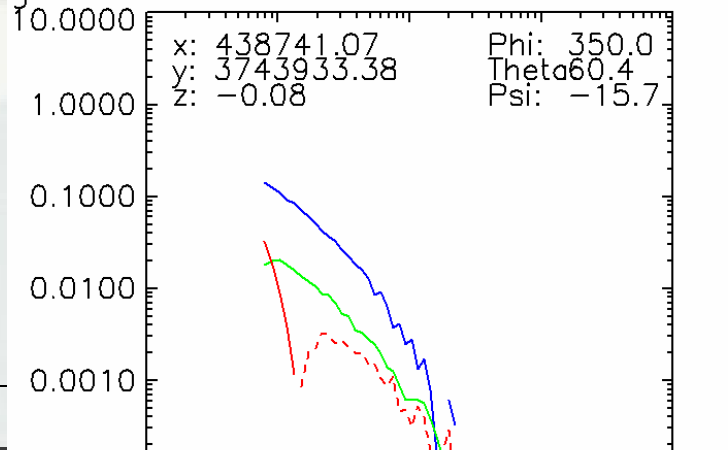
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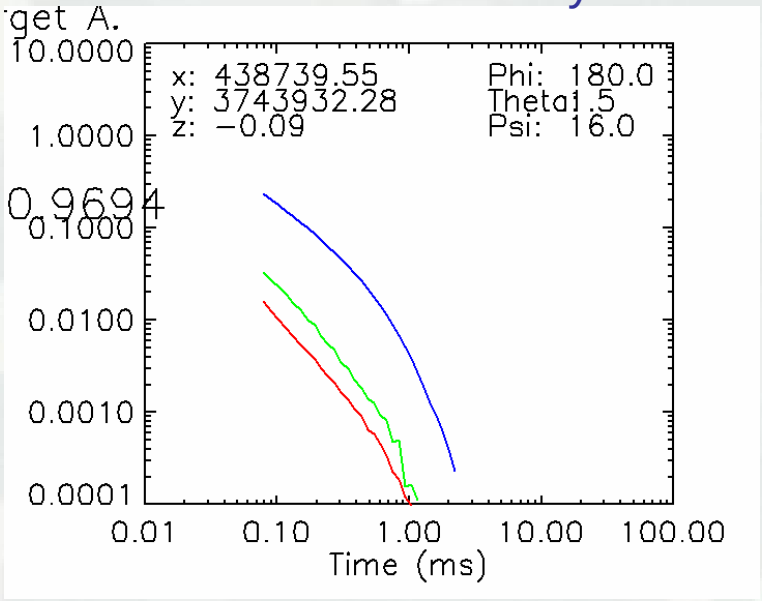
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Analyze For Clusters Example

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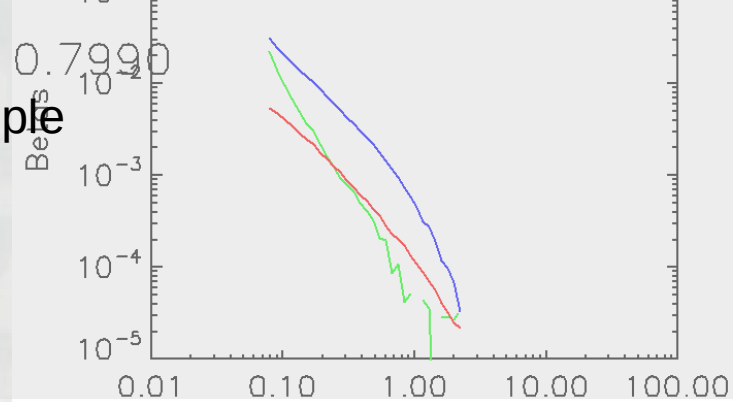
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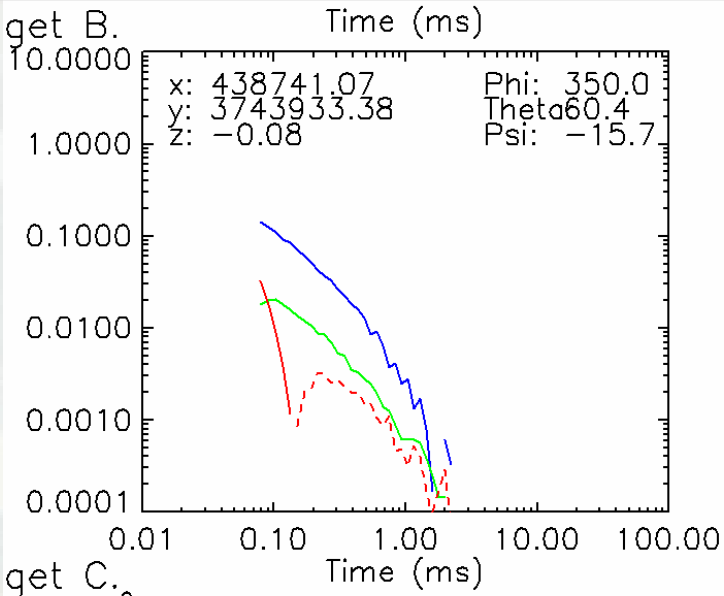


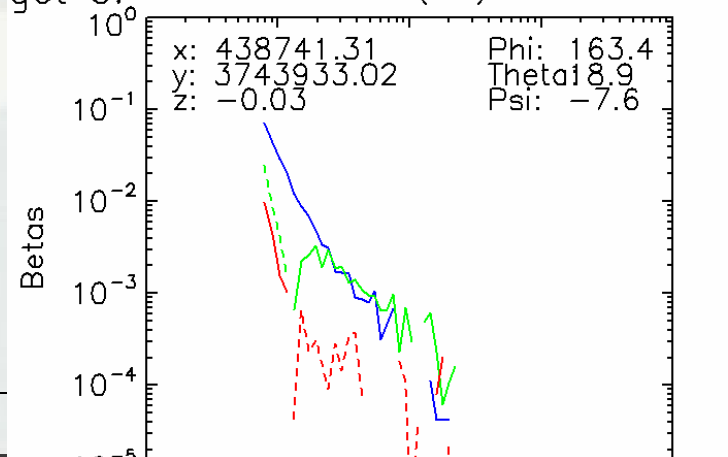
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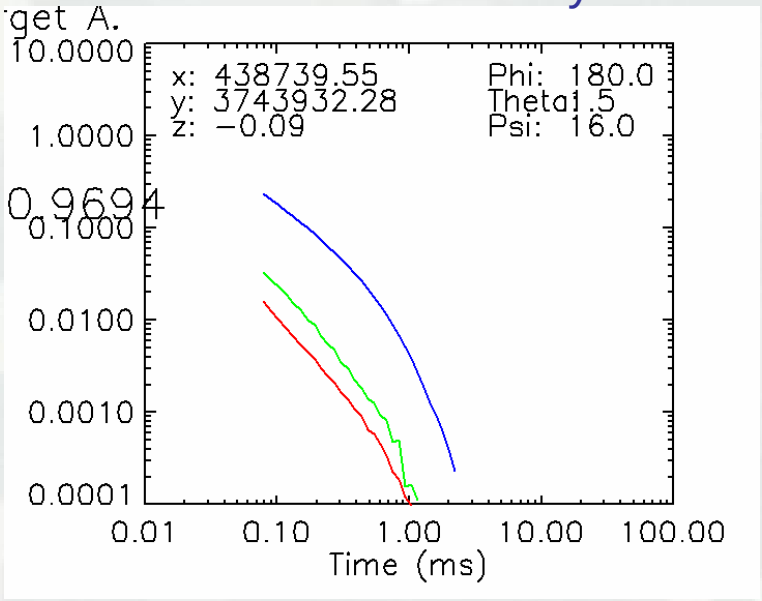




Analyze For Clusters Example

Match Better Than 0.95?

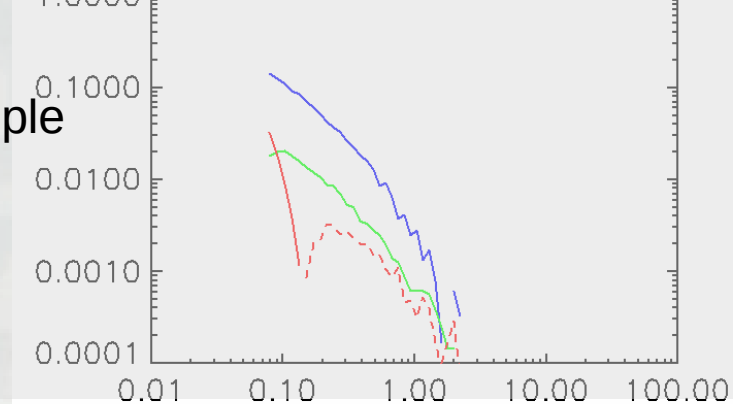
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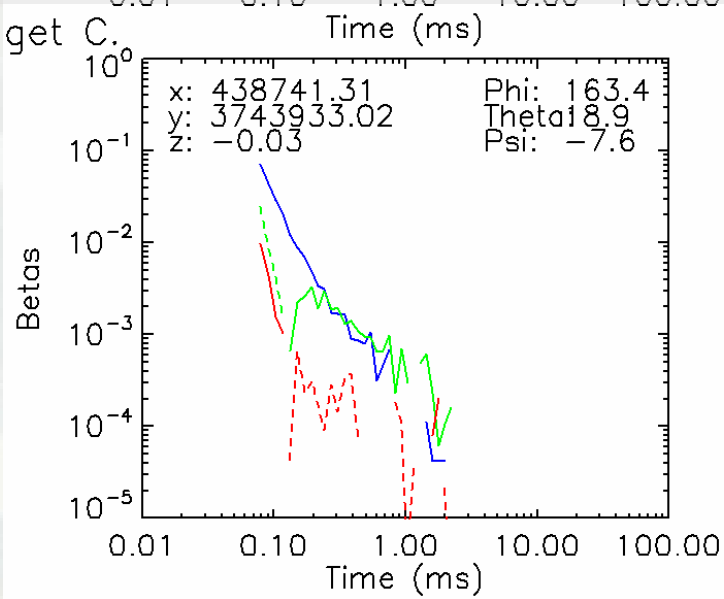


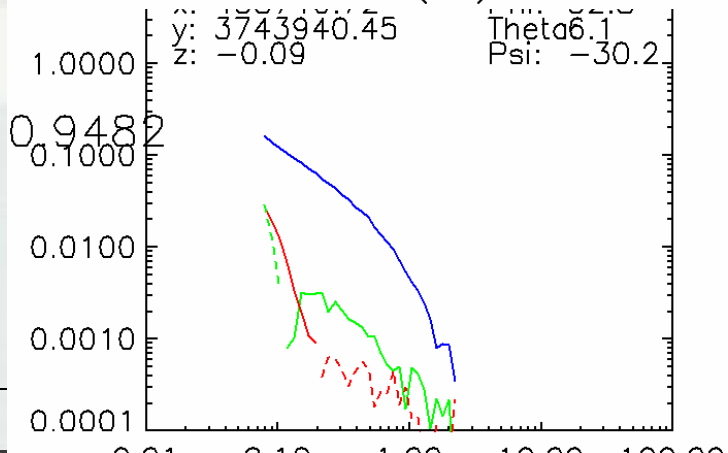
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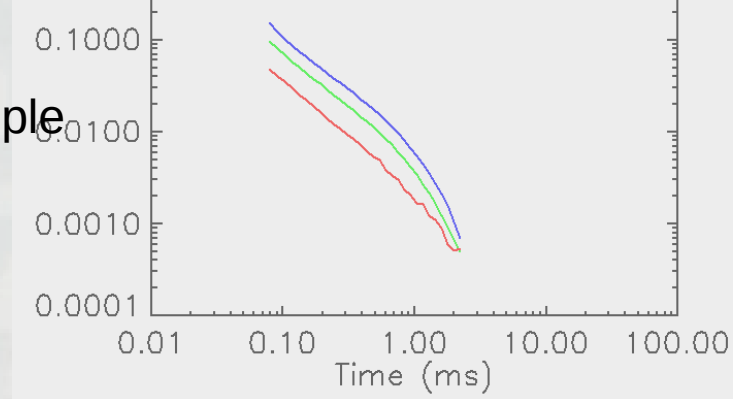




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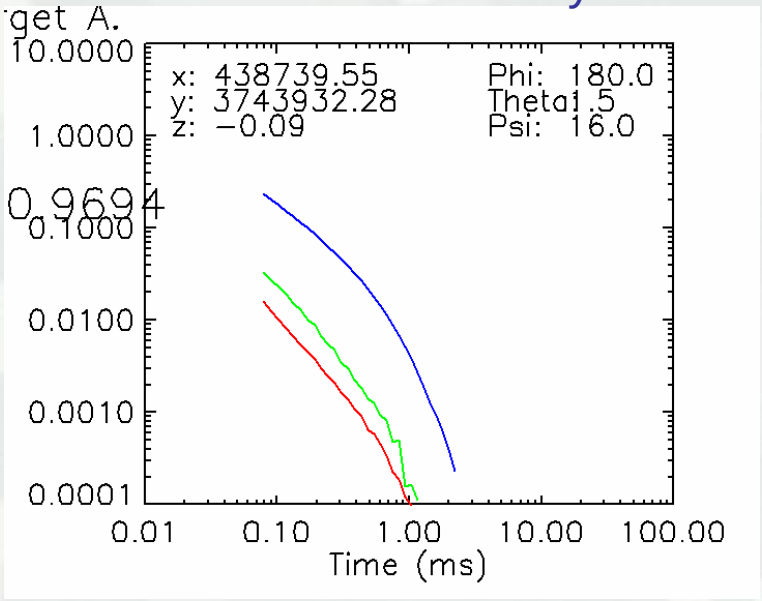
Analyze For Clusters Example

0.17



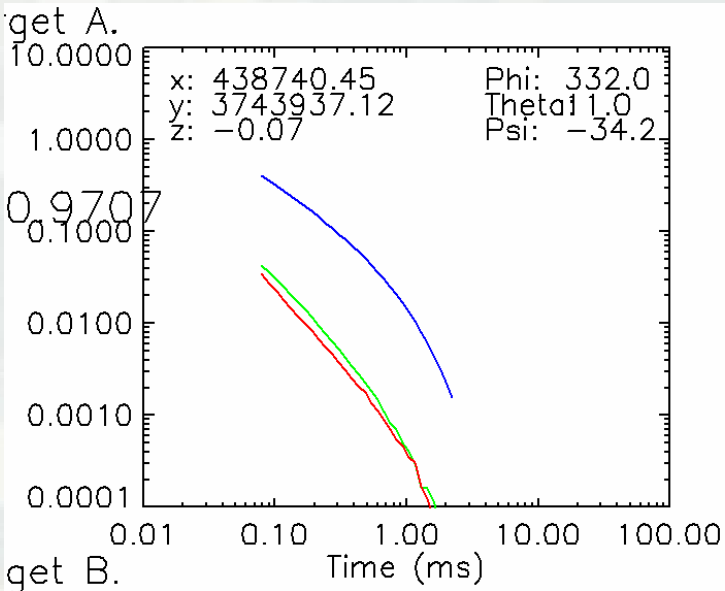
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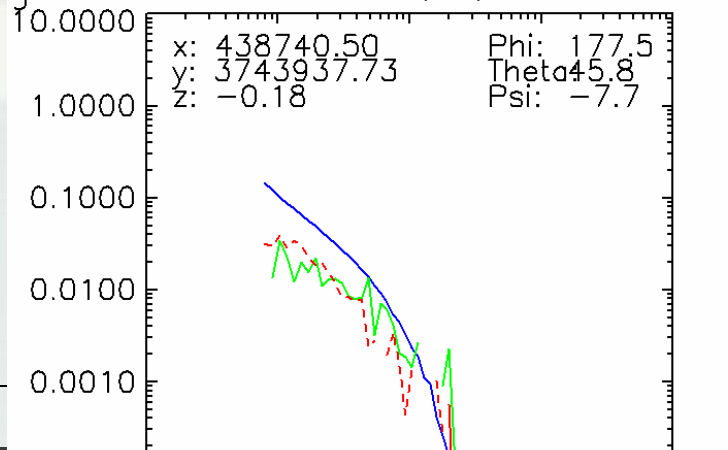


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0.95

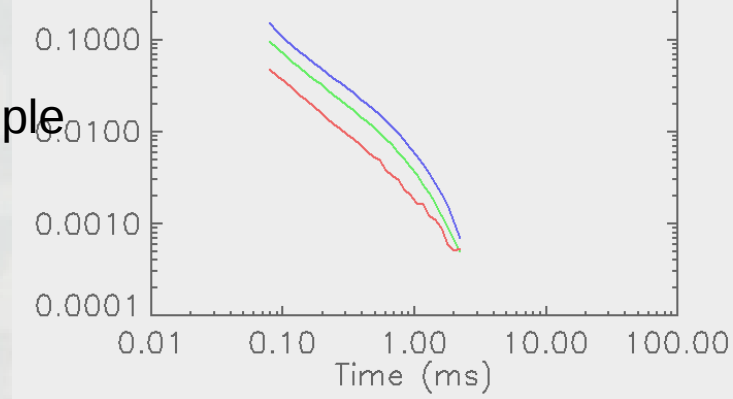


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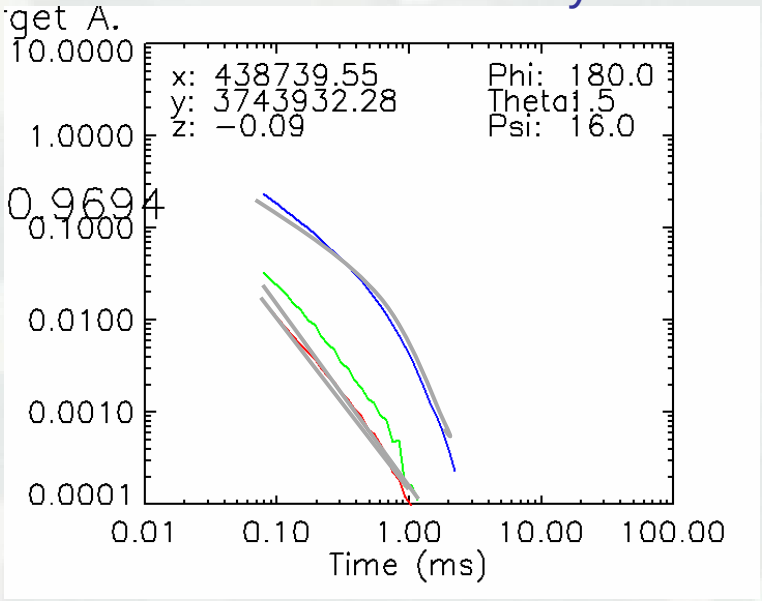
Analyze For Clusters Example

0.17



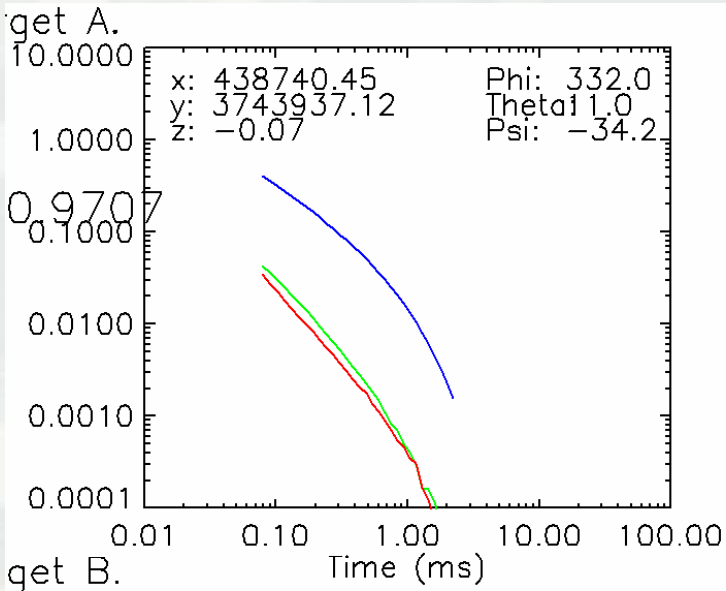
Match Better Than 0.95?

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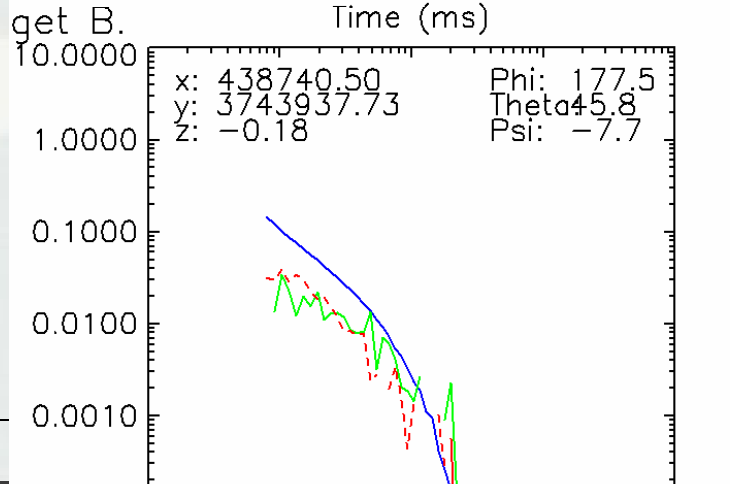


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0.95



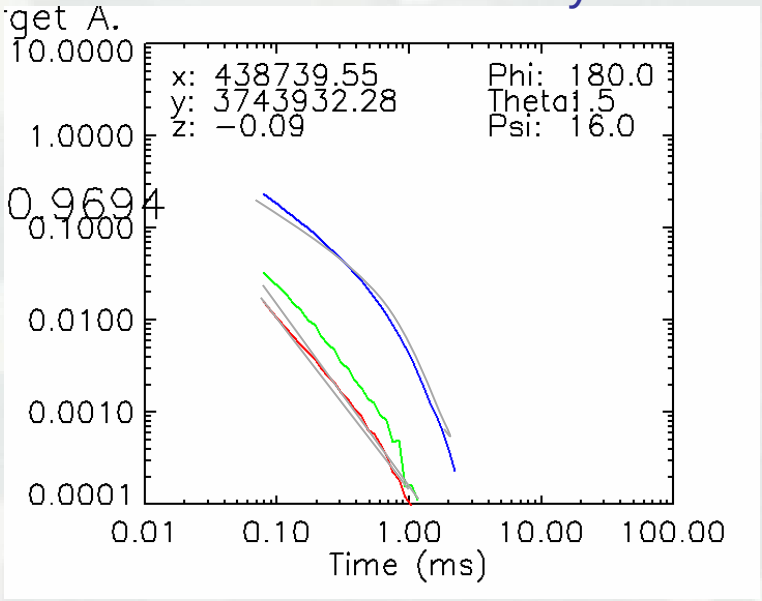
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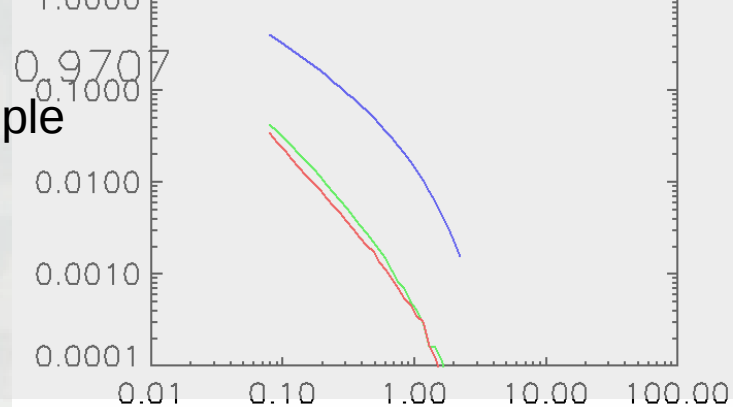
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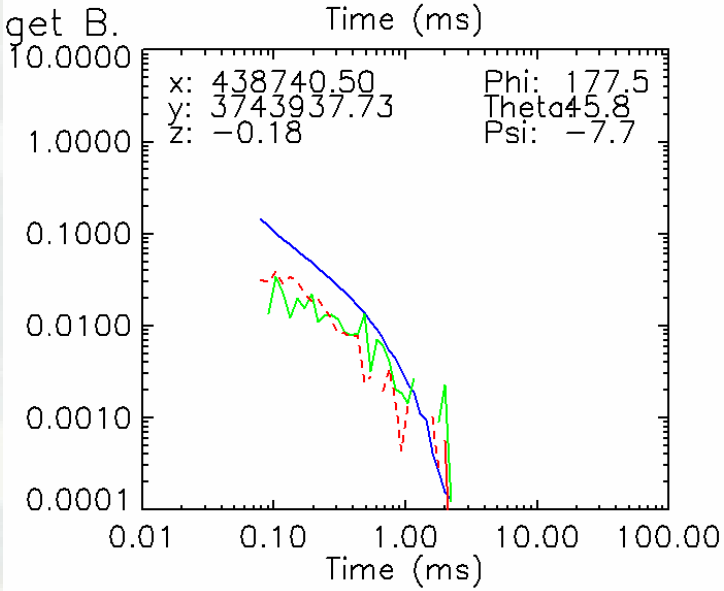
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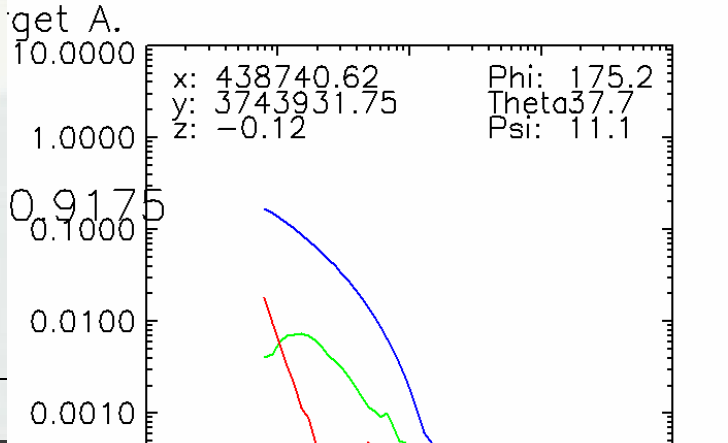
The basis of comparison signature
aka “The Library”



0.11



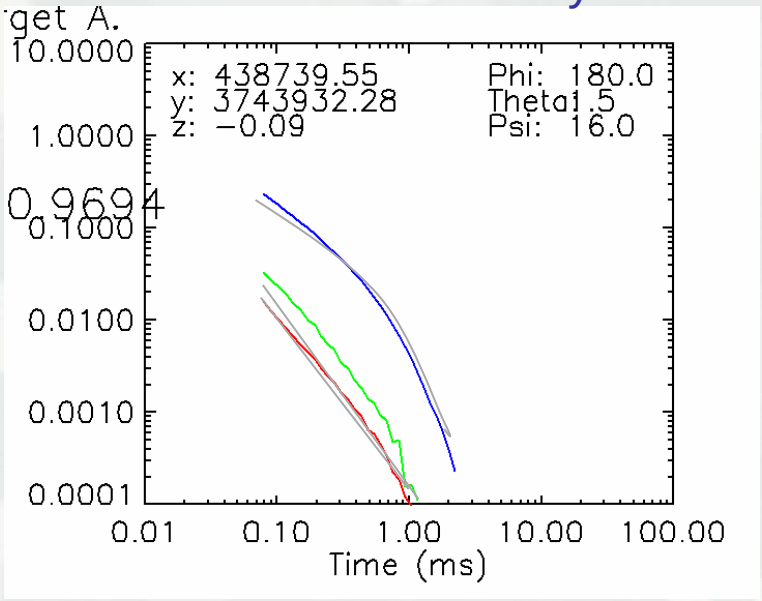




Analyze For Clusters Example

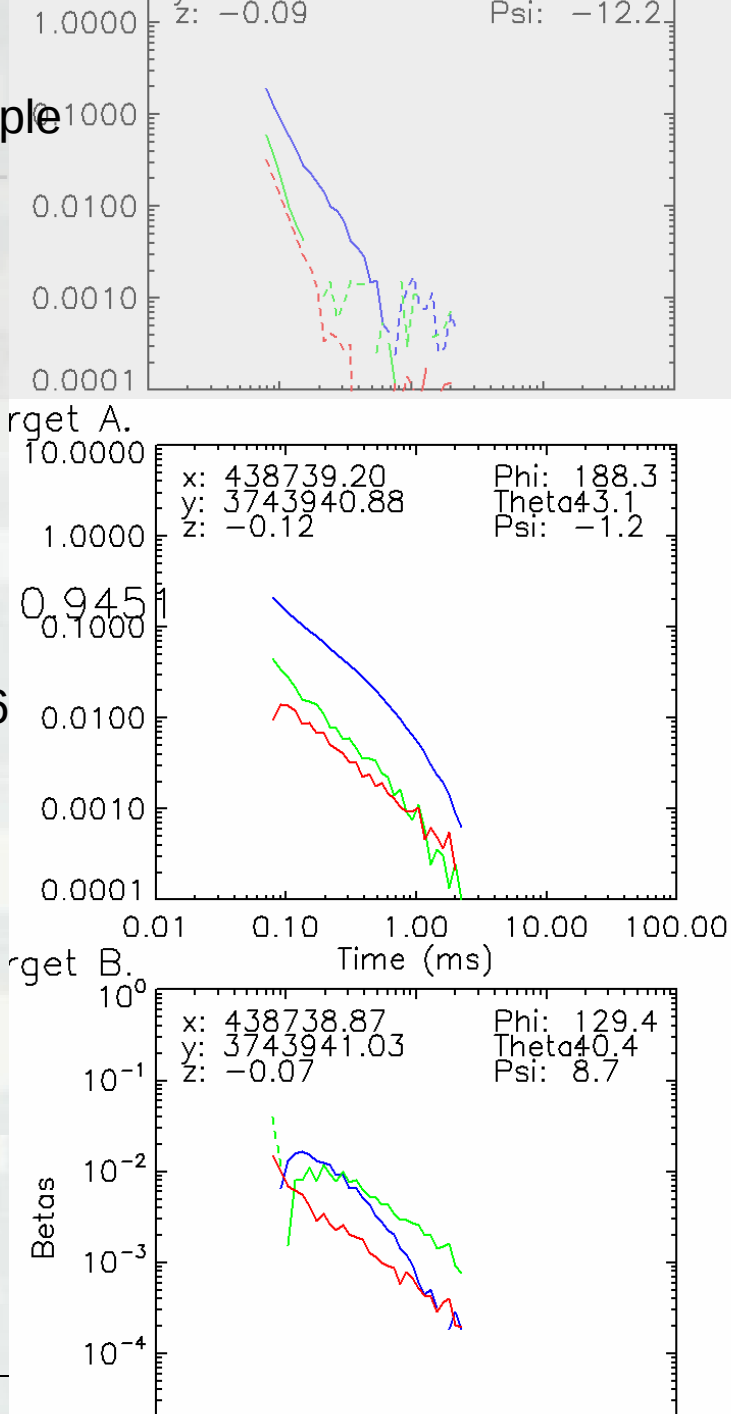
Match Better Than 0.95?

The basis of comparison signature
aka “The Library”



0.9694

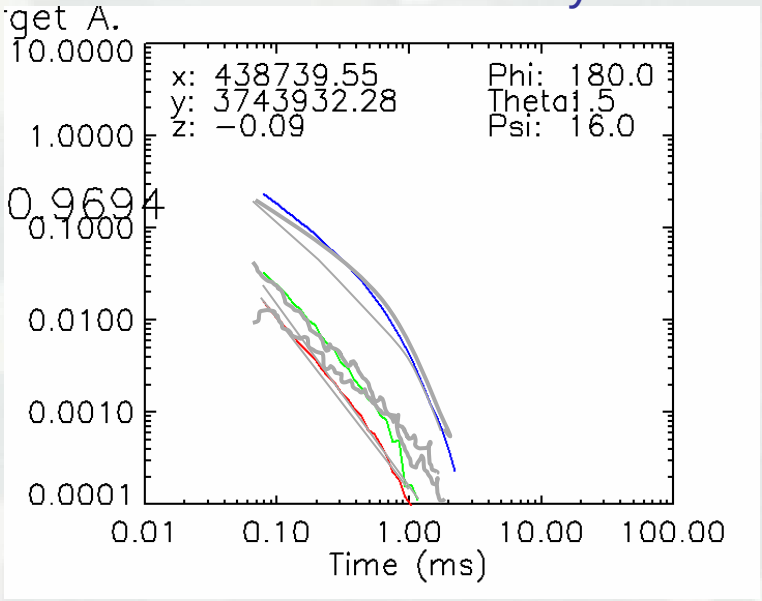
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Analyze For Clusters Example

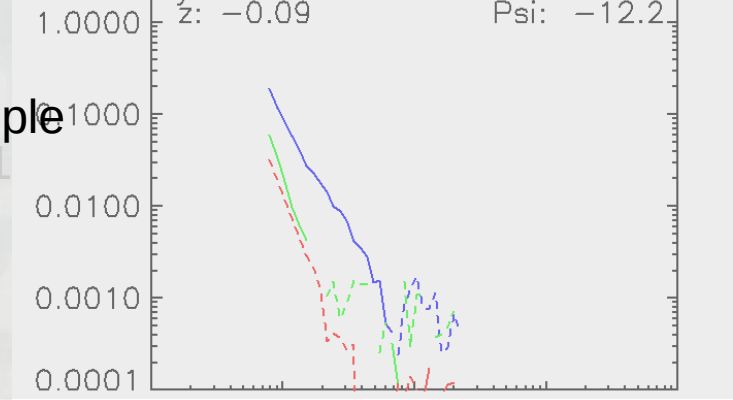
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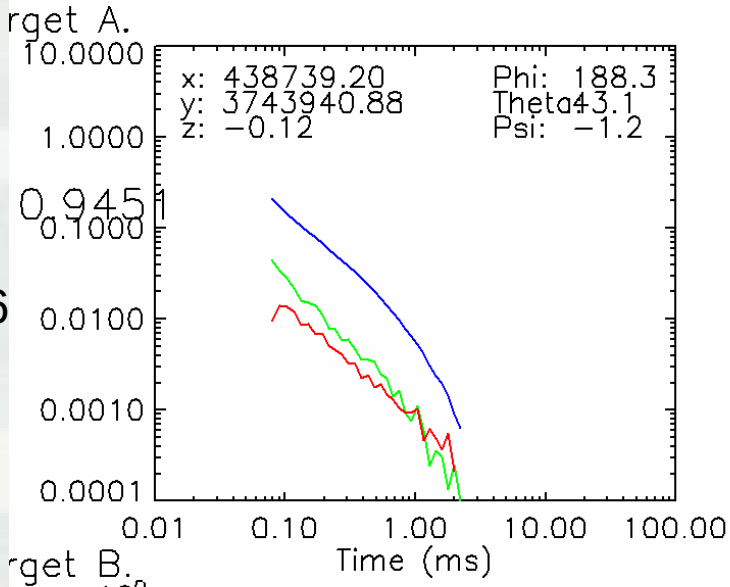
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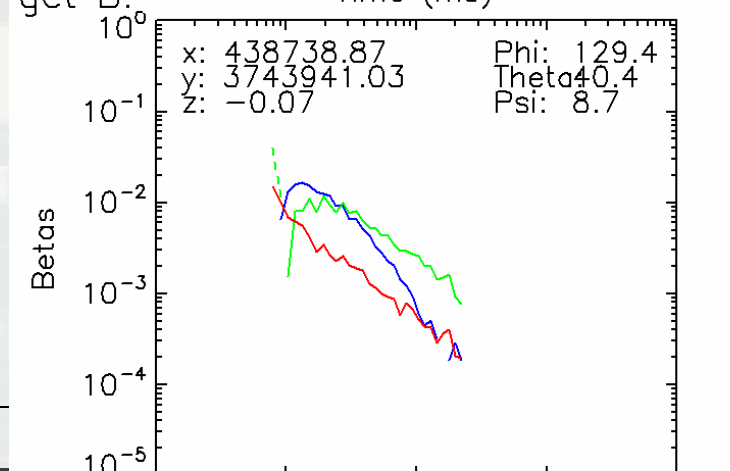
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0.96





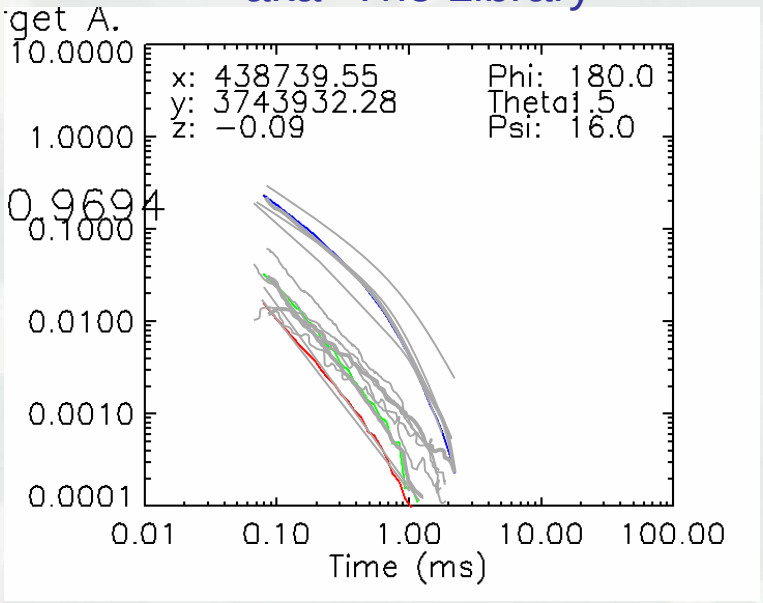
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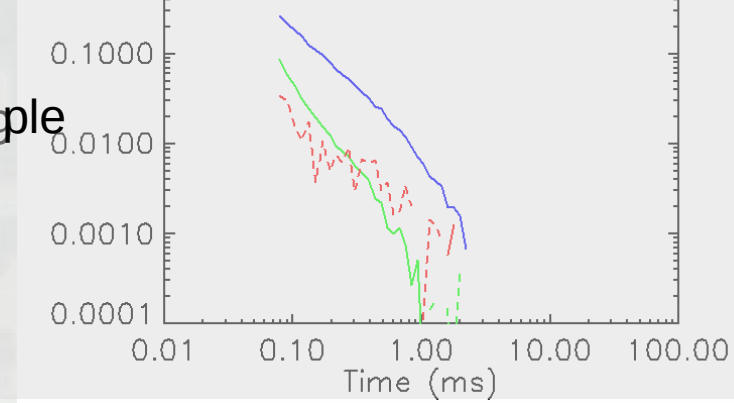


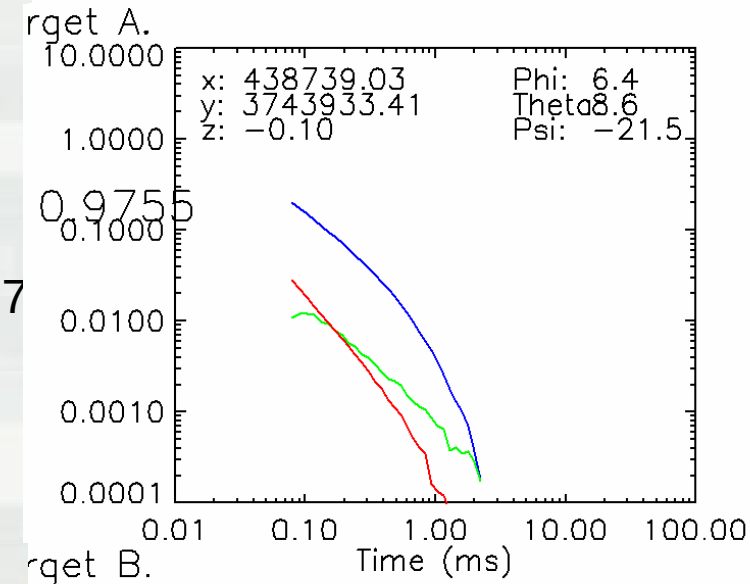
Analyze For Clusters Example

Match Better Than 0.95?

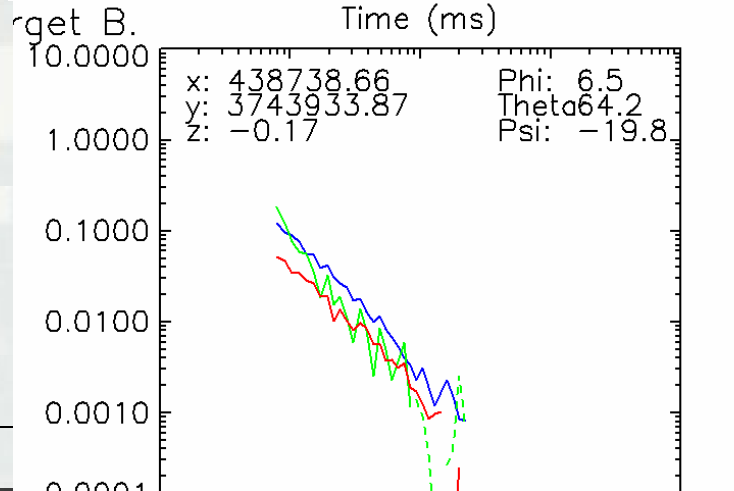
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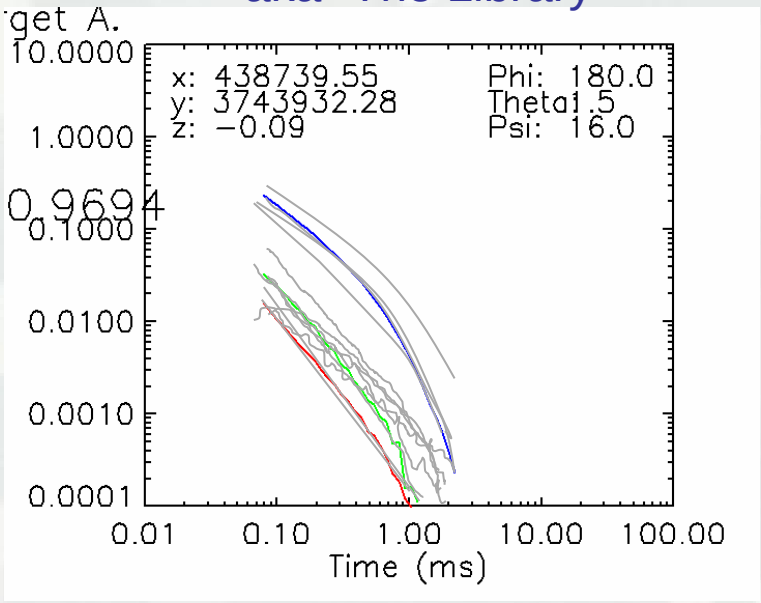
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Analyze For Clusters Example

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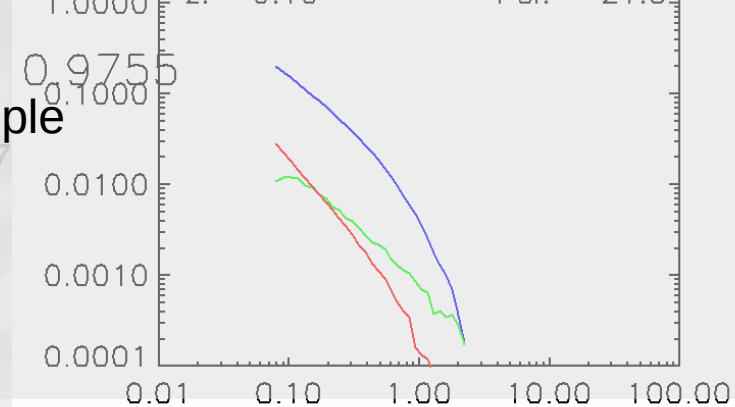


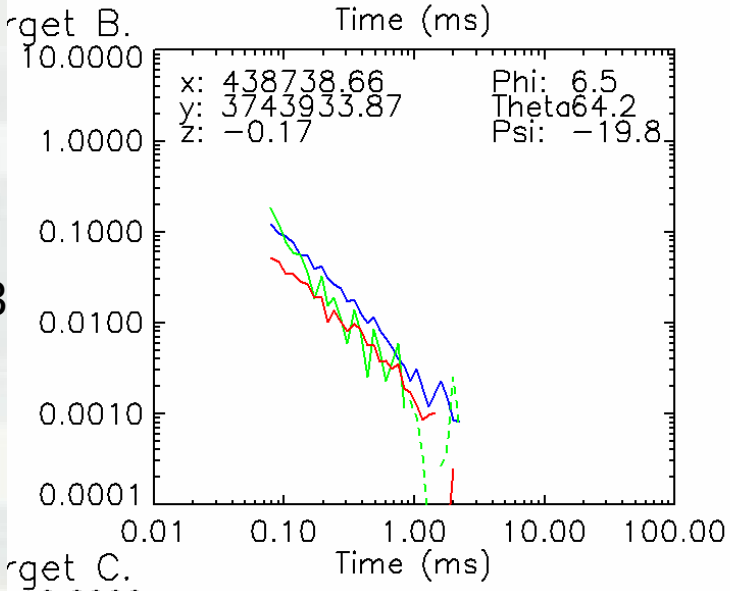
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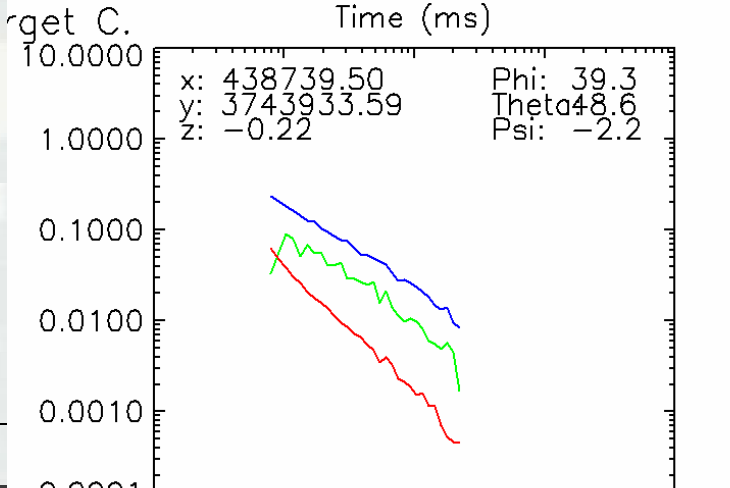
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0.97

0.13



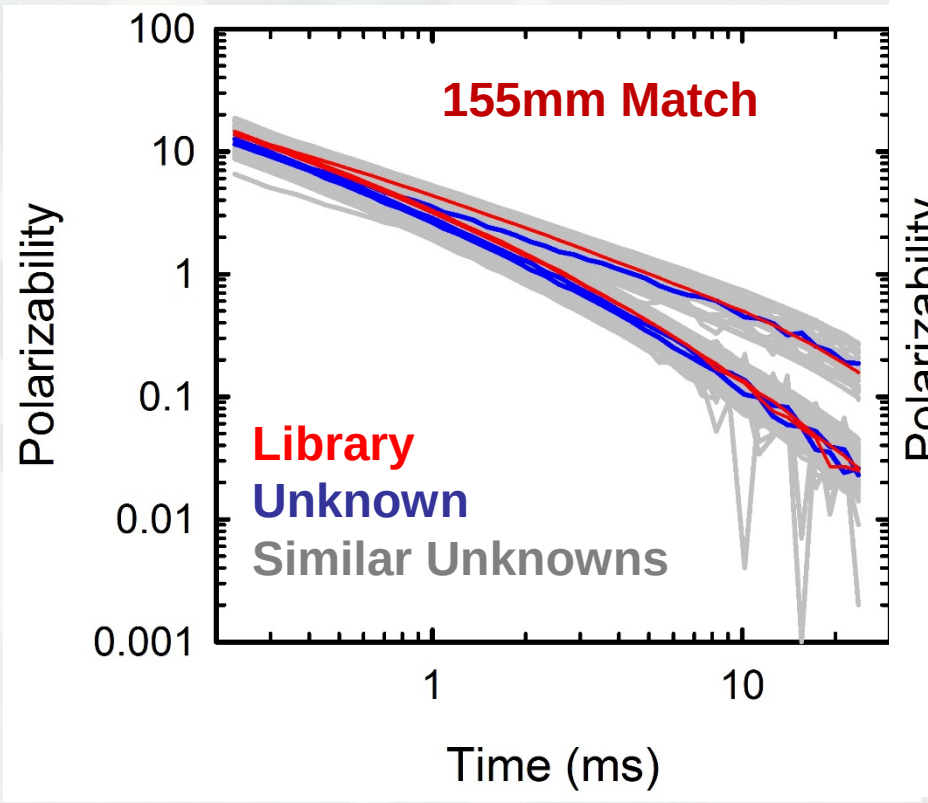


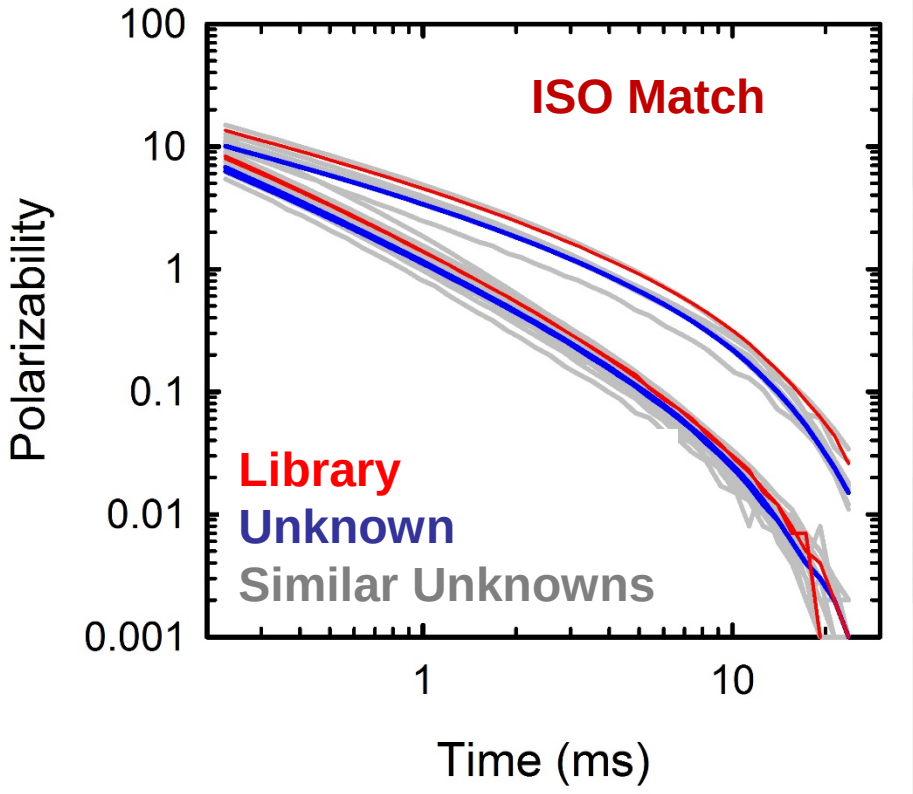


And on…and on…and on…

Compare each signature to all other signatures on site

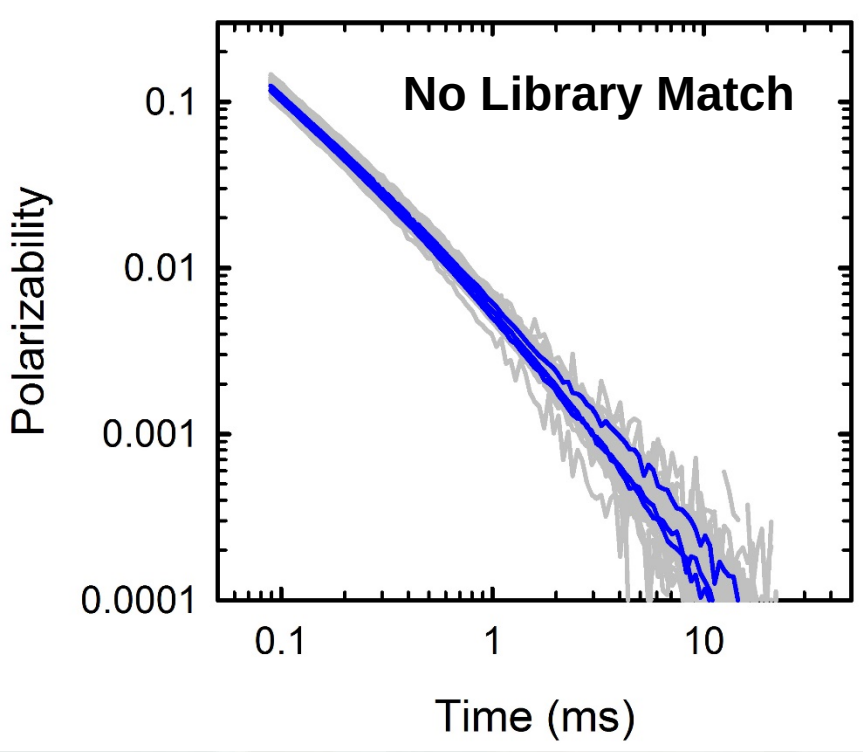
- look for clusters (groups of items with similar response)
- most clusters correspond to things we know about, like these two examples

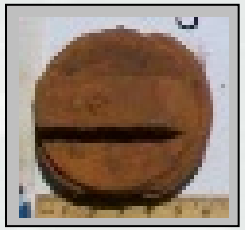




Compare each signature to all other signatures on site

- If there are clusters of items that do not match the library signatures, we excavate some of them and proceed accordingly…





T-Bar Fuze
Non-hazardous clutter,
did not add to library

Classification Techniques Summary

- Library Matching
  - Asks what an unknown target “looks like” in EMI sense
  - Compares polarizability against bank of signatures for expected munitions and other training objects
- Be a Cluster of things of interest
  - Same-shaped objects have the same polarizabilities
  - Groups of identical things that turn out to be UXO
- Be Large, long, axisymmetric and thick-walled



Something New…sort of…

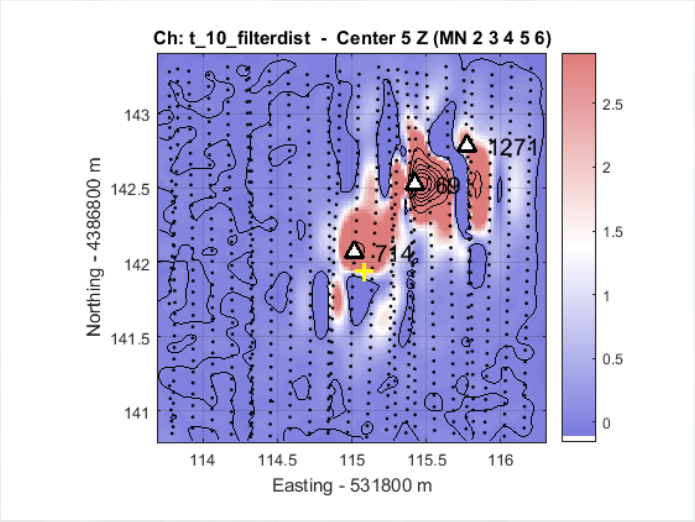
- Informed Source Selection (formerly called Informed Source Identification and Selection until Abu Bakr al-Baghdadi was named as Caliph!)

How it works

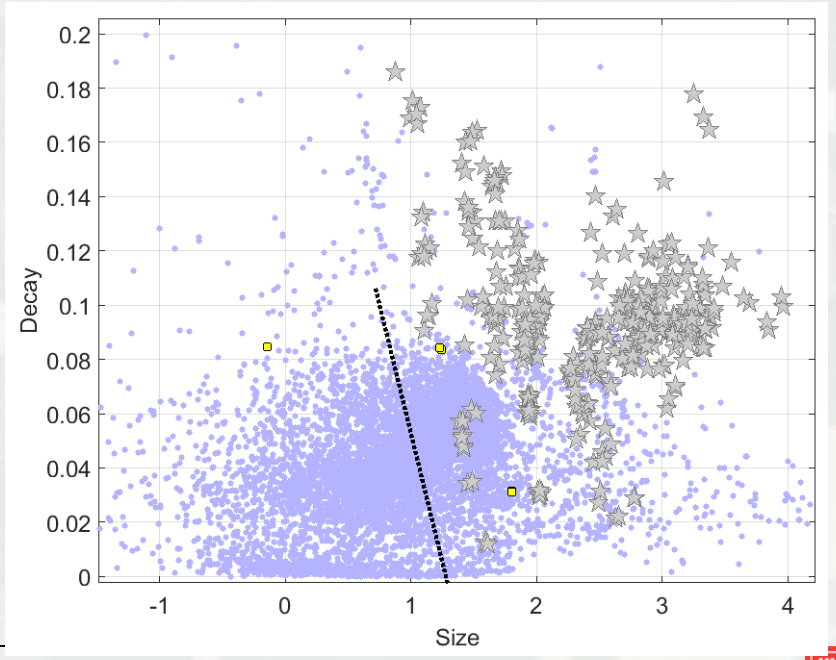
- Uses new sensors in dynamic (detection) mode
- Collects lower volume of data, at a much higher rate (~10Hz vs. 0.01-0.03Hz)
- Uses same inversion process to get size and wall thickness
- Culls really small anomalies off the cue list

Two Stage Process

- Stage 1: Find anomaly locations



- Stage 2: Calculate parameters and screen

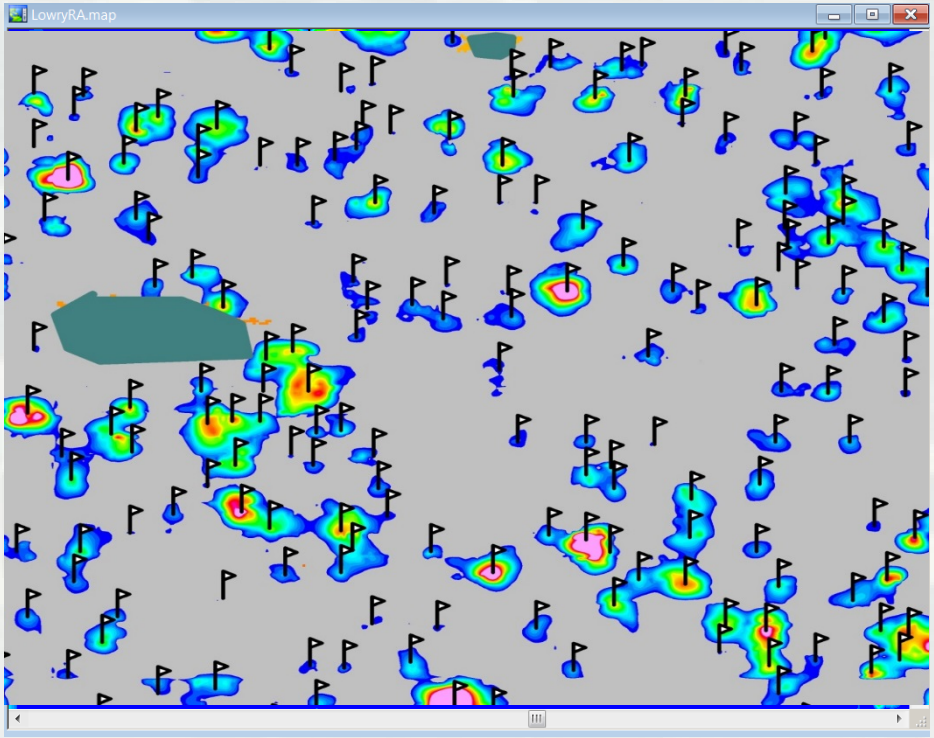


Stage 1: Detect Anomalies

Two ways of doing this:

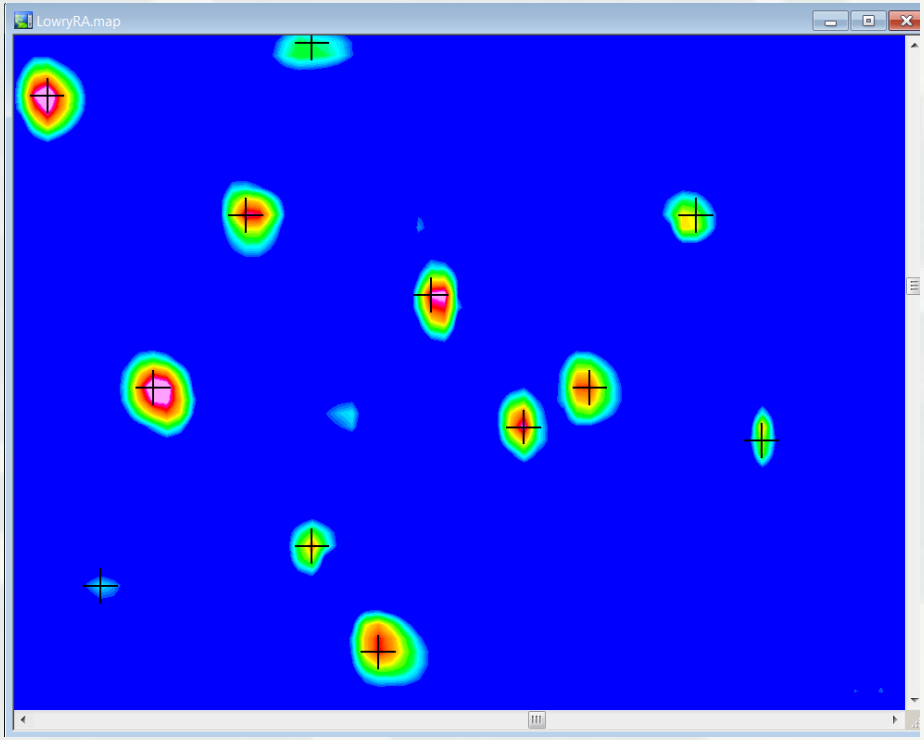
Look For Peaks

- TEMTADS TzRz Signal



Look For Metal

- Dipole Inversion Output

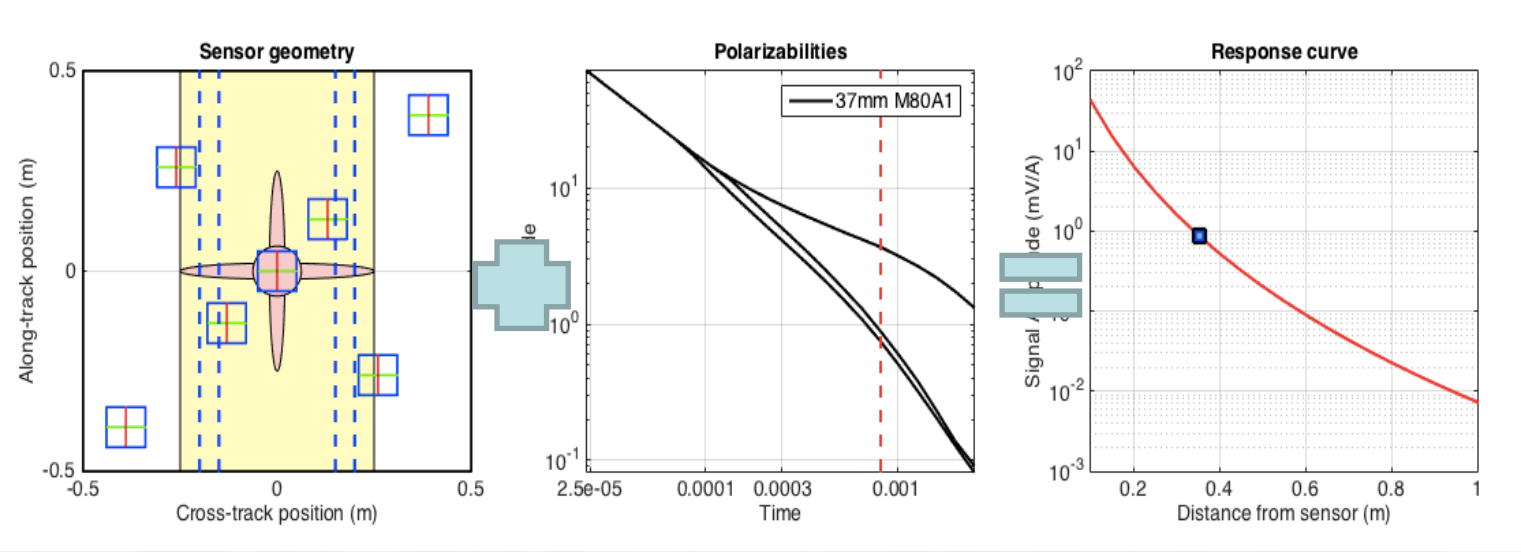


BUILDING STRONG®

Detect Anomalies: Look For Peaks

WAIT! What Threshold Do We Use?

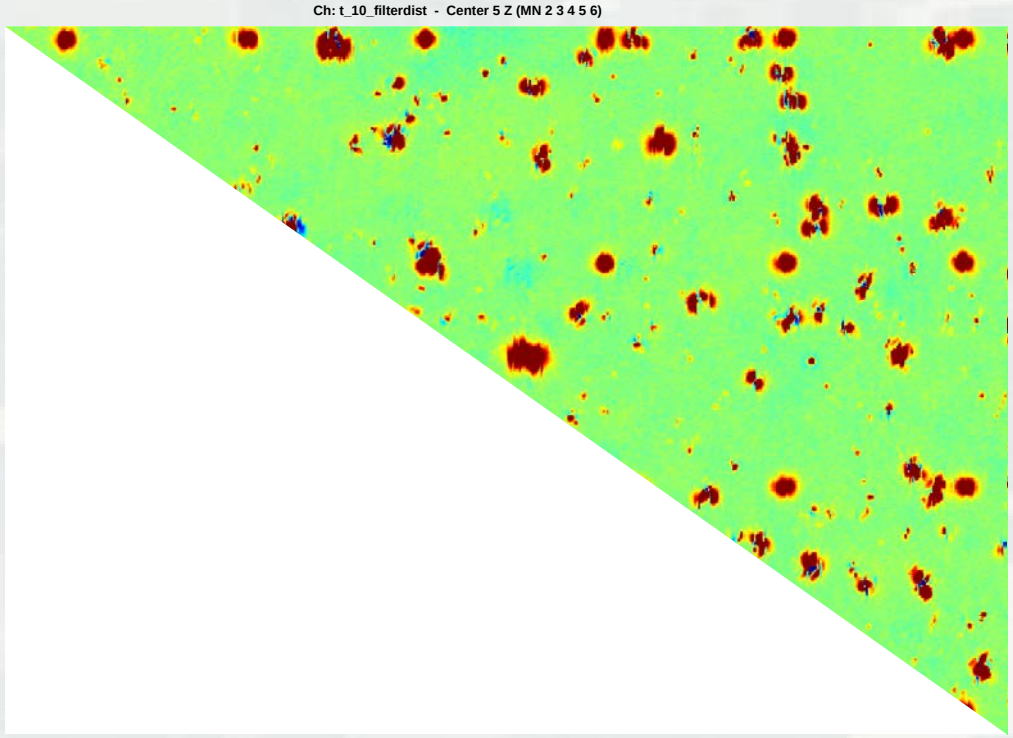
- Three-steps process:
- Step 1: Calculate threshold for vertical (z) component data
  - ► All calculations for smallest or most difficult TOI to detect
  - ► All calculations for worst case scenario
  - ► Artificially add noise & superimpose on real site data



Detect Anomalies: Look For Peaks

WAIT! What Threshold Do We Use?

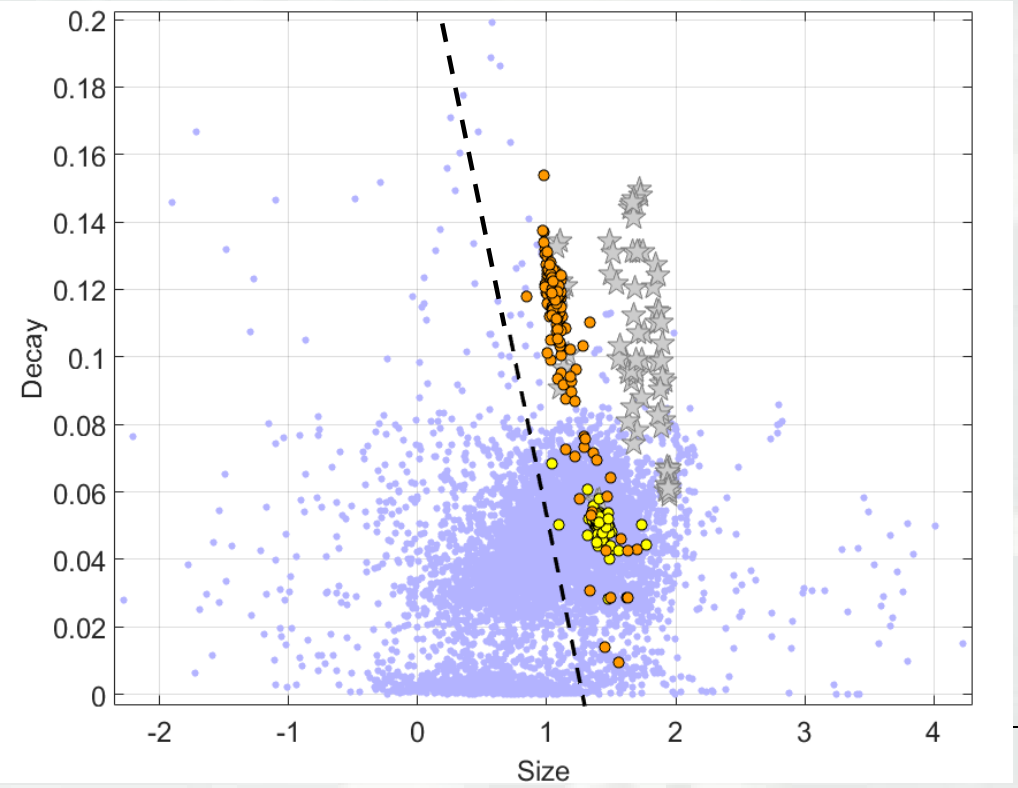
Step 2: Synthetic Seeding & Monte Carlo Simulations



Can Do This For Any Number Of TOI
(shown here: 20mm TP added at white triangle locations)

Step 3: Invert & Analyze All Monte Carlo Simulations

- Run regular inversion at each detected anomaly (figure below)
- Adopt a conservative approach: only anomalies that can be declared non-TOI with high confidence can be removed



Example for 3 small artificially seeded TOI:
20mm TP (orange circles)
20mm AP (yellow circles)
37mm AP (grey stars)

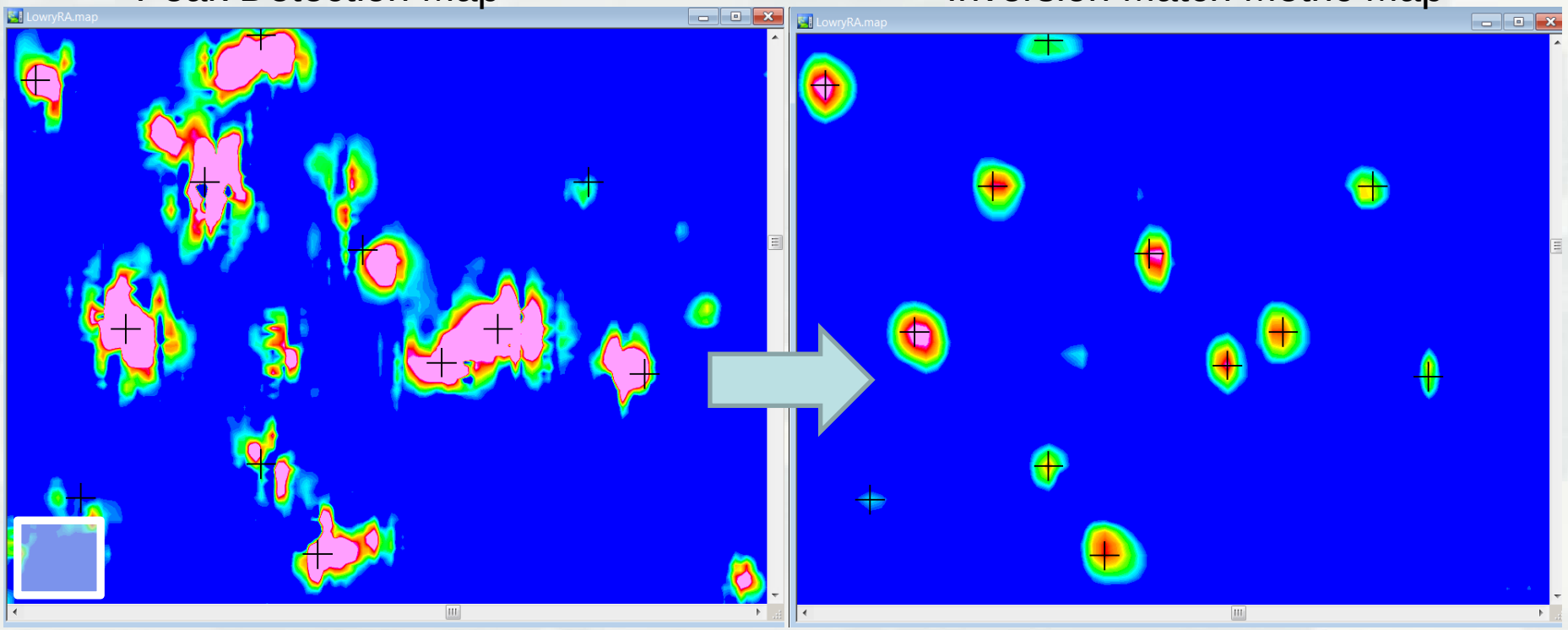
→ all other detected anomalies: Purple dots

Detect Anomalies: Look For Metal

- Invert a square meter of data every 10cm assuming a smallest TOI or larger piece of metal is present
- Resulting Map = How well inversion matches data

Peak Detection Map

Inversion Match Metric Map



Where We Are Now

Diversity of Deployment Platforms

- MetalMapper











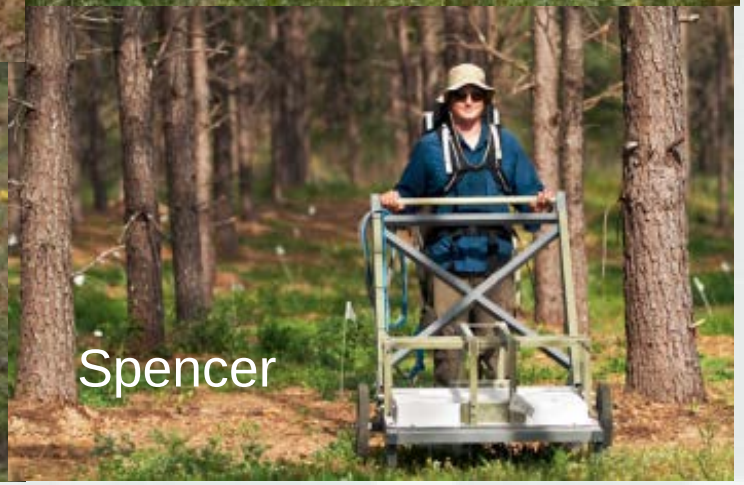
Diversity of Deployment Platforms

- TEMTADS 2x2



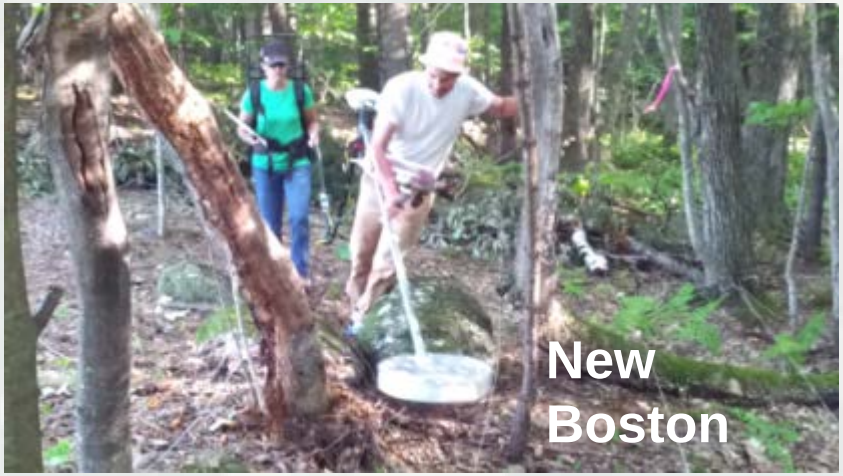


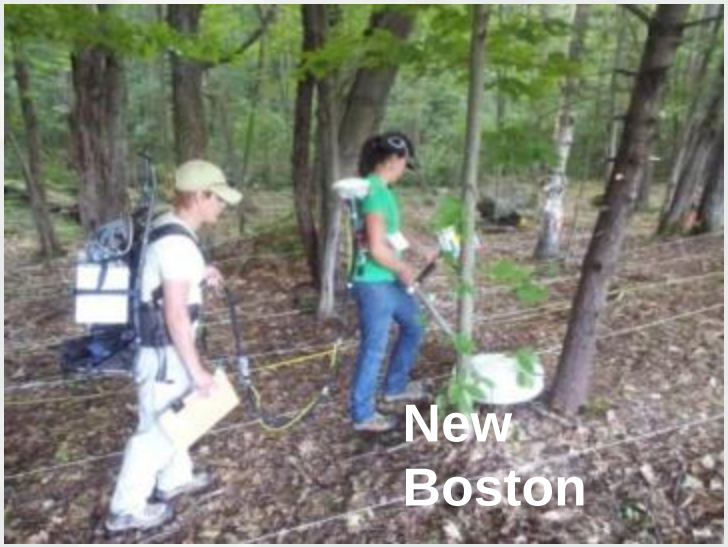




Diversity of Deployment Platforms

- MPV





Dynamic (GPS or Line/Fiducial)



Cued (local Beacon positioning)

Potential Savings on a 100-acre Site

Item	Units	Cost				
Mob/Demob	1	$25,000	range: $15,000 to $30,000			
Surface Sweep	acre	$1,500	range: $500 to $5,000			
IVS	each	$6,000	One day of three-person crew			
Seed Emplacement	per day	$5,250	assumes 25 seeds emplaced per day, crew size of 3			
EM61 Data Collection and Analysis	acre	$1,000	range: $1,000 with array to $5,000 with single sensor			
Dynamic TEMTADS Collection and Analysis	acre	$6,000	range: $3,300 to $5,500			
Cued TEMTADS Collection and Analysis	per anomaly	$40				
Intrusive Investigation	per dig	$120	range: $75 to $200			

	Traditional Approach – No Classification		**Classification**	
Mob/Demob	= unit costs	$25,000	same as traditional	$25,000
Surface Sweep	= 100 acres * per acre	$150,000	same as traditional	$150,000
IVS	= unit cost	$6,000	same as traditional	$6,000
Seed Emplacement	= 25 QC + 25 QA	$10,500	= 200 QC + 200 validation	$84,000
EM61 survey and analysis	= 100 acres * DGM costs	$100,000	n/a	
Dynamic TEMTADS	n/a		= 100 acres * TEMTADS costs	$600,000
Cued TEMTADS	n/a		= 50% reduction from advanced analysis	$1,000,000
Seeds Dug	= seeds * cost per dig	$6,000	= seeds * cost per dig	$48,000
Native UXO Dug	= # UXO * cost per dig	$60,000	same as traditional	$60,000
Clutter Dug	= # clutter * cost per dig	$5,940,000	= 80% clutter rejection	$1,188,000
Fixed Costs		$400,000		$400,000
Total		**$6,697,500**		**$3,561,000**

Not Only Direct Cost Savings

- Fewer holes → less environmental damage
  - Wetlands
  - Sensitive environments
  - Golf courses
- Fewer digs → less disruption and fewer evacuations

Is Classification Applicable at This Site?

- **If EM61 or Magnetometer Today, Then YES!**
- What are the targets of interest at this site?
  - Historical research
  - Recovered munitions and fragments/scrap
  - Depth and density



Photo courtesy of Estrella Warbirds Museum

Classification Planning

- What classification sensor is appropriate for the site?
  - ► Benign terrain
    - MetalMapper
  - ► Rougher terrain with steeper slopes and trees
    - TEMTADS 2x2, MPV, Handheld BUD



MetalMapper



TEMTADS 2x2



MPV

Photos courtesy ESTCP

Classification Planning (cont.)

- What parts of the site have an anomaly density that will allow classification to be successful and at what cost?
  - ► Small sites and densities greater than 3K to 4K per acre may not be appropriate
  - ► For sites with few anomalies, the costs of remediation must justify the extra expense required for data collection
    - Wetlands, chemical sites, sensitive habitat, disruptive evacuations, land owner needs, public interest etc.

Not Appropriate



Landfill Surprise

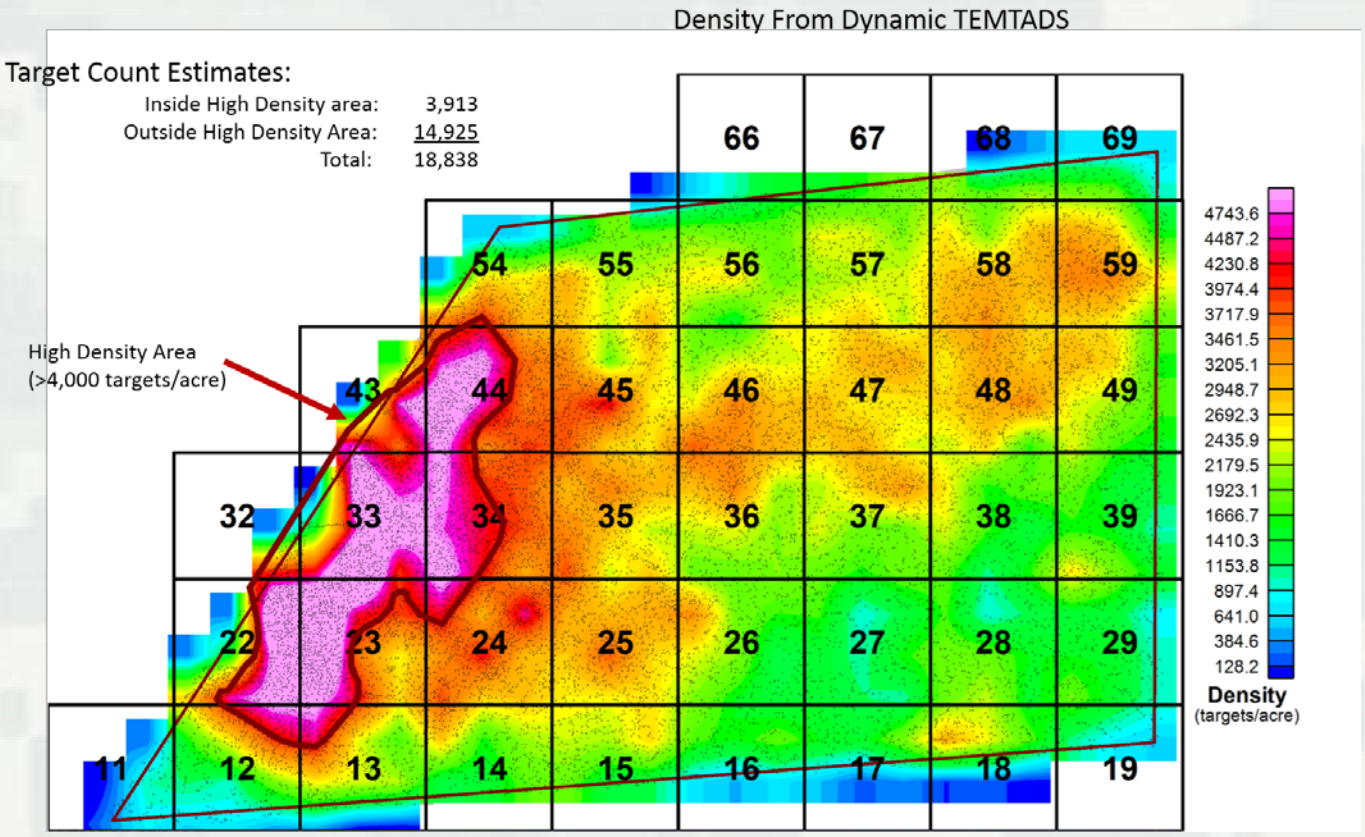
Appropriate



40-mm Anti-Aircraft Projectile

Photos courtesy U.S. Navy

Classification – Where We Stand And What It Means



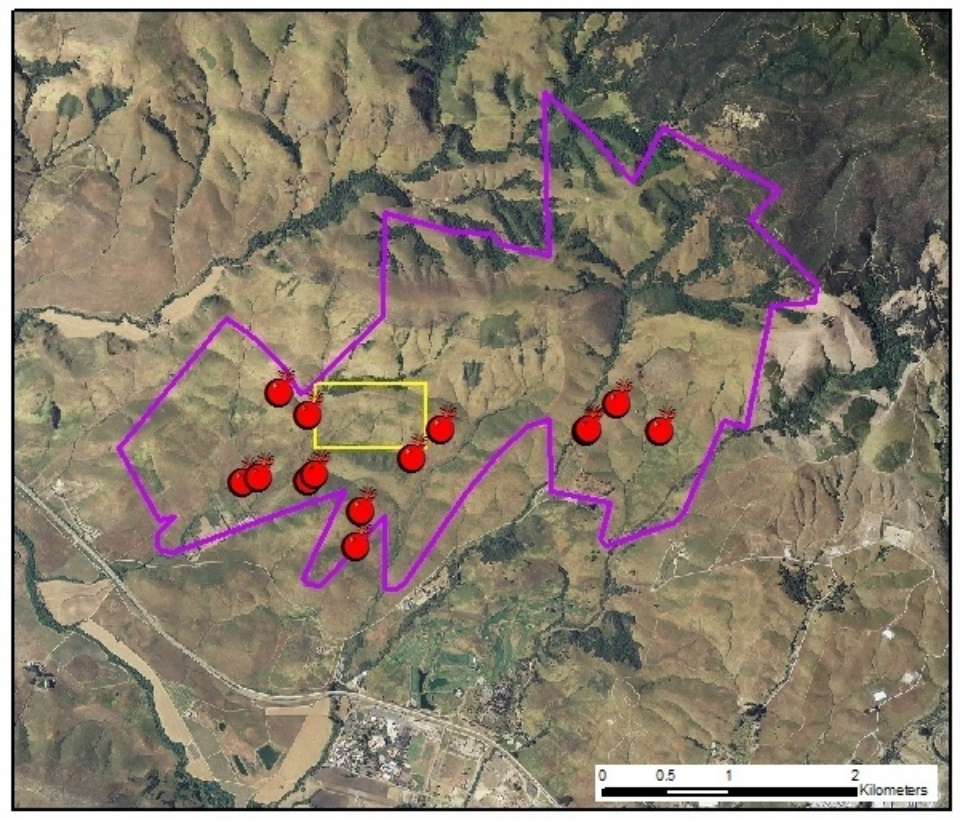
Former Camp San Luis Obispo
37 mm projectiles to 155mm projectiles

It works a lot better than we imagined

- Even with seven different UXO in the site
- Even with 37mm projectiles
- Even in up to 4,000 anomalies per acre

Example
Full-Scale Application

Example Site

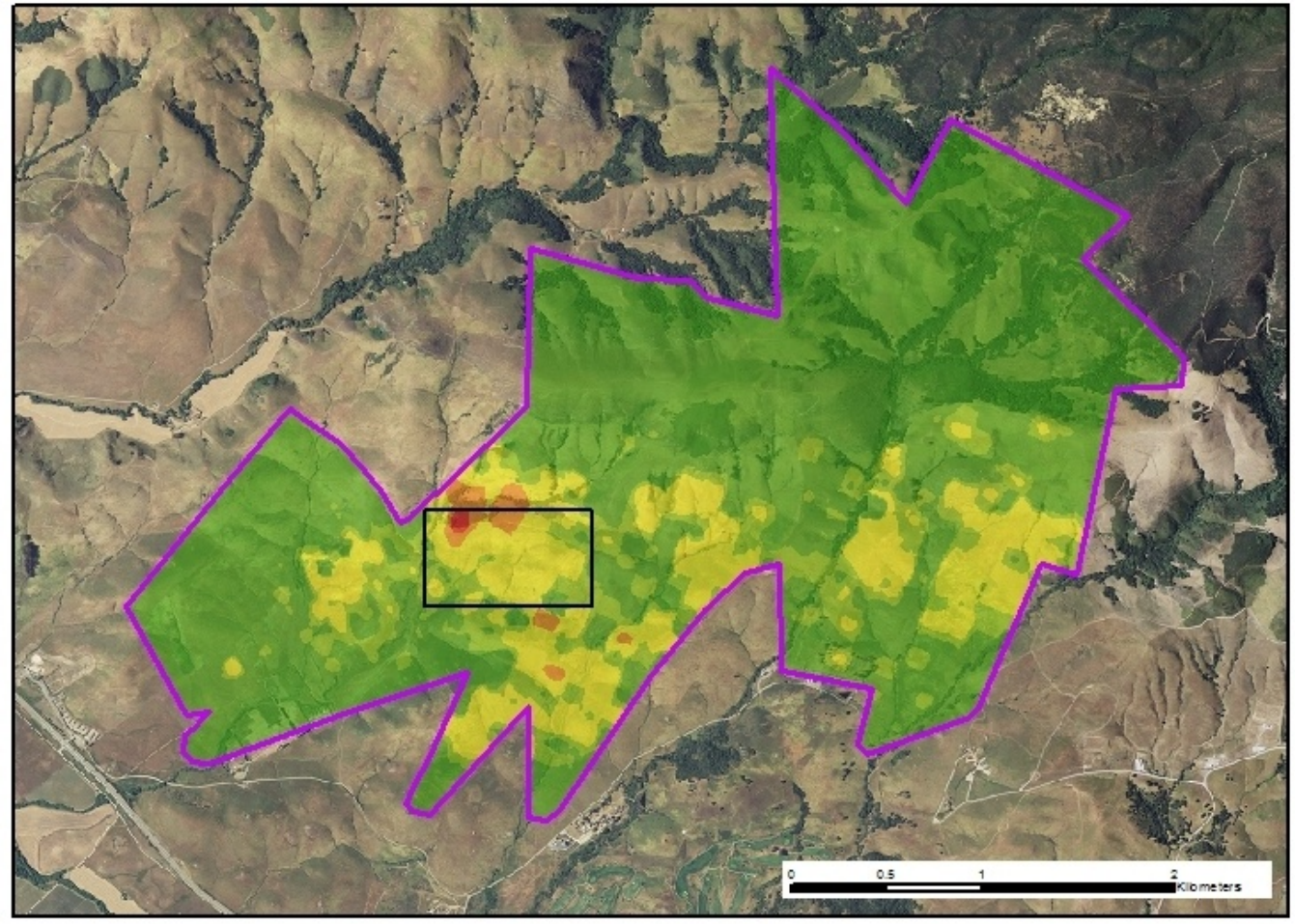


- University owned
  - ► No access restrictions
  - ► Cattle grazing
  - ► Geotechnical classes
  - ► Camping
- Multiple, overlapping range fans
- MRS ~ 2,500 acres
- 100 acres in Year 1

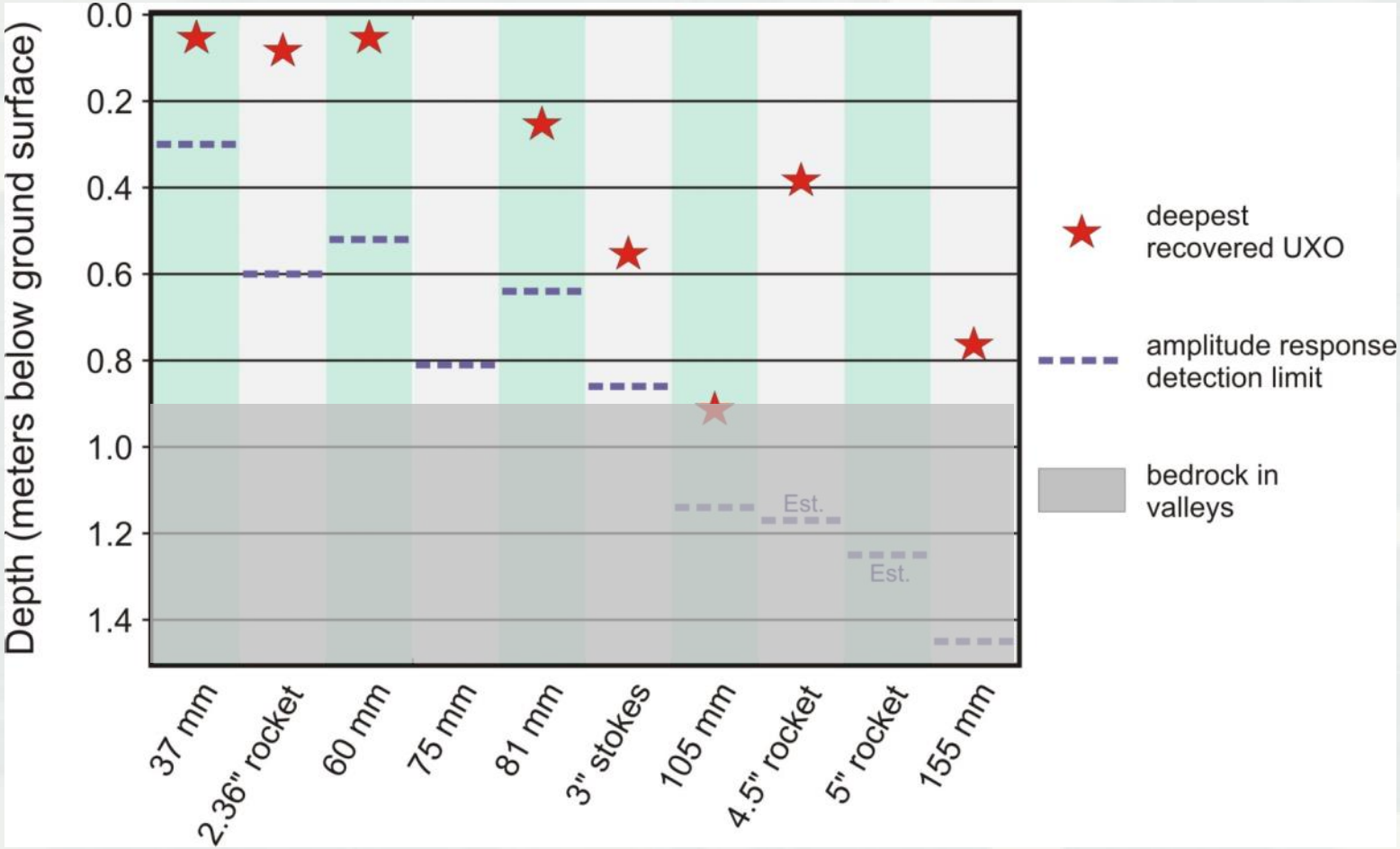
Site History

- Initially established in 1928
- Expanded during WWII
- Transferred to private owners after Korean War
- Previous investigations
  - Preliminary Assessment (1986 and 1993)
  - Time Critical Removal Action (1992)
  - Archives Search Report (1994)
  - Site Inspection (2007)
  - Time Critical Removal Action (2010)
  - Remedial Investigation (2011)

CSM – Spatial Distribution of MEC



CSM – Vertical Distribution of MEC



Remedial Objective

- Detect and dispose of MEC that can be detected using a detection threshold required to detect a 37mm projectile at 12 inches below the ground surface, and to do so as efficiently as possible
  - Remove any MEC detected irrespective of depth
  - As efficiently as possible = most economical method to accomplish remedial objectives

Projected Costs for Year 1

Item	Units	Cost	
Mob/Demob	1	$25,000	range: $15,000 to $30,000
Surface Sweep	acre	$1,500	range: $500 to $5,000
IVS	each	$6,000	One day of three-person crew
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Fixed Costs		$400,000		$400,000
Total		$6,697,500		$3,561,000

Intial TPP Meeting

- Agree on:
  - Remedial Objective
  - Survey lane spacing
  - Anomaly selection methodology
    - Advanced detection methods
  - Sensor Selection
  - Schedule
  - …..

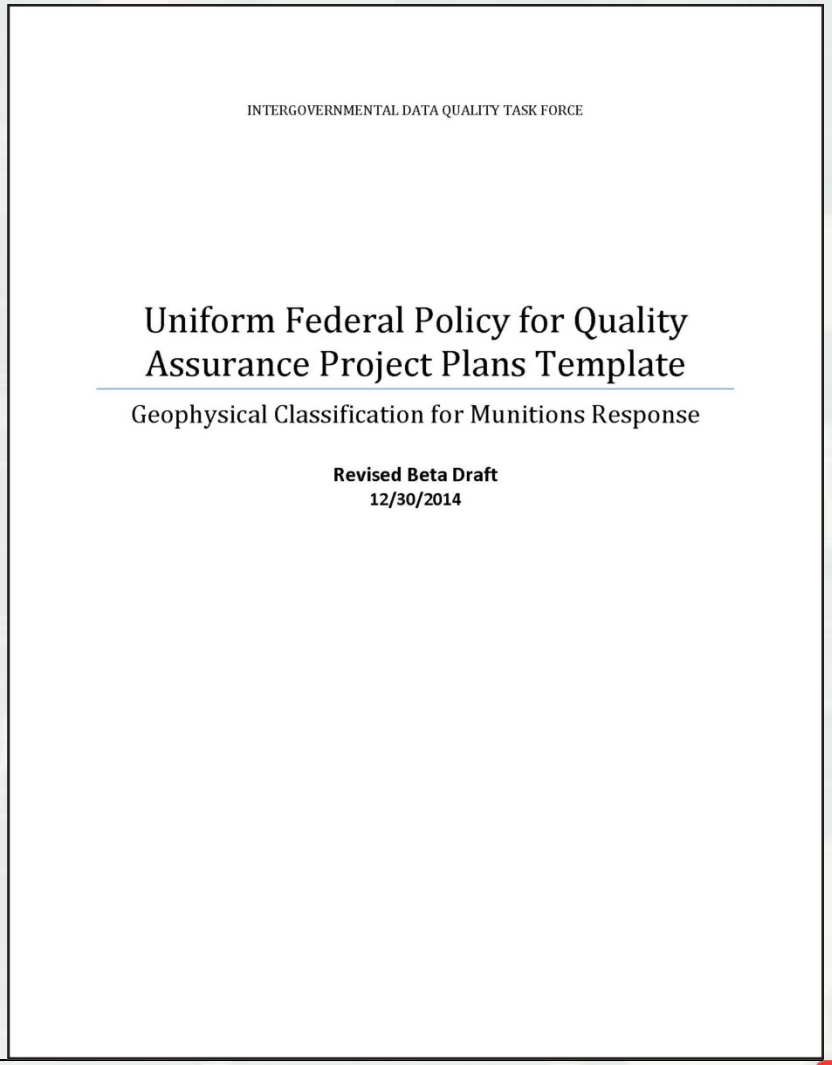


MR Project Work Elements that Classification Significantly Changes

- GIS setup
- Document management and control
- Subcontracting
- Technical and operational approach
- Work Plan preparation and approval
- Site prep and mobilization
- Site survey/grid layout
- Vegetation removal
- Surface removal
- Geophysical System Verification (GSV)
- Geophysical survey, data collection, and processing
- Anomaly reacquisition and investigation
- MEC/MPPEH management
- Demobilization
- Final report
- Archiving
- Project closeout

Geophysical Classification for Munitions Response-Quality Assurance Project Plan (…or GCMR-QAPP)

- What follows is based on beta draft template



INTERGOVERNMENTAL DATA QUALITY TASK FORCE

Uniform Federal Policy for Quality Assurance Project Plans Template

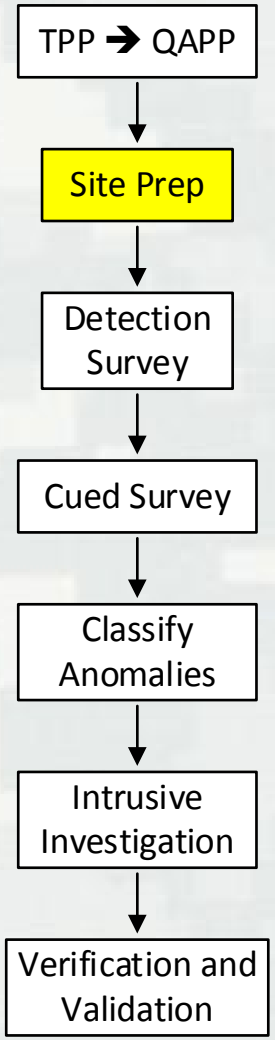
Geophysical Classification for Munitions Response

Revised Beta Draft
12/30/2014

Project Workflow

TPP → QAPP	DFWs	Example Tasks	Products
Site Prep	1,2	Surface Clearance QC & QA Seed Emplacement IVS Construction	Surface Clearance Tech Memo QC Seed Emplacement Memo Validation Seed Memo (Govt Only)
Detection Survey	3,4,5	Dynamic Survey Anomaly Selection	IVS Tech Memo Weekly QC Submittal Anomaly Selection Memo
Cued Survey	6,7	Background Data Collection Anomaly Data Collection	IVS Tech Memo Weekly QC Submittal
Classify Anomalies	9,10	"Training" Digs Construct Ranked Anomaly List	Classification Tech Memo Ranked Anomaly List
Intrusive Investigation	11	Dig Items Compare Recoveries to Predictions	Intrusive Investigation Report Photos Final Draft Validation Plan
Verification and Validation	12	Verify Thresholds Validate Process	Final Report

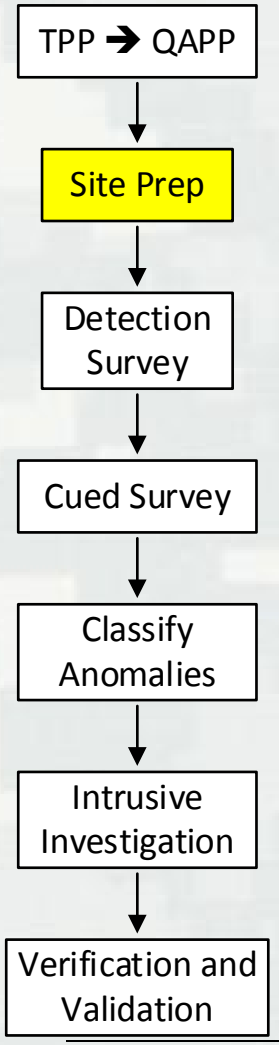
Surface Clearance Memo



- Was everything found consistent with the CSM?
- Is there anything the analysts need to know?
- Opportunity for cost savings

CSM	Evidence from Surface Sweep?
37-mm projectile	Y
2.36-in rocket	Y
60-mm mortar	Y
75-mm projectile	Y
81-mm mortar	N
3-in stokes mortar	Y
unexpected munition	N

Contractor's QC Seeds

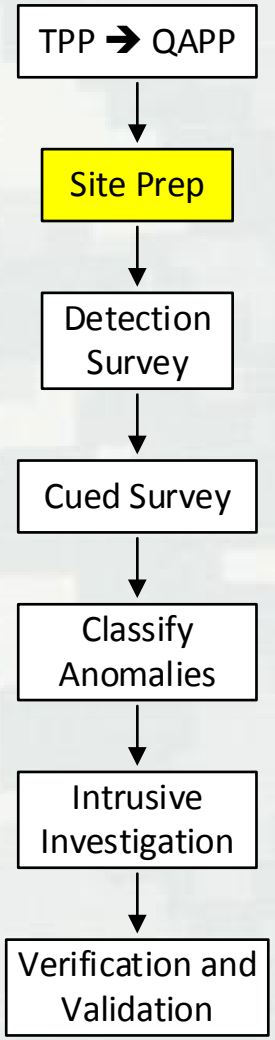


- Inert 37-mm projectiles and small ISO80s
- 200 QC seeds, approximately 50% of each
- Seeds placed at six depths up to the maximum PWS detection depth (5, 10, 15, 20, 25, & 30 cm)





Government Validation Seeds



- ~200 seeds
- Small ISO80, 37-mm projectiles, mortars
- Full depth range of interest
  - 30 cm for small ISO and 37mm
  - 45 cm for 60-mm mortar
  - 65cm for 81-mm mortar

IVS Construction

- TPP ➔ QAPP
- **Site Prep**
- Detection Survey
- Cued Survey
- Classify Anomalies
- Intrusive Investigation
- Verification and Validation



IVS Tech Memo

TPP ➔ QAPP

Site Prep

Detection Survey

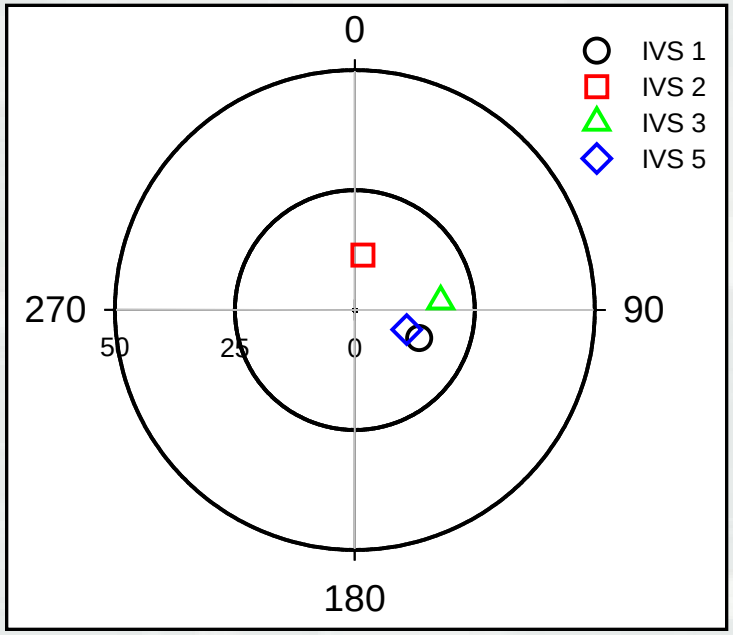
Cued Survey

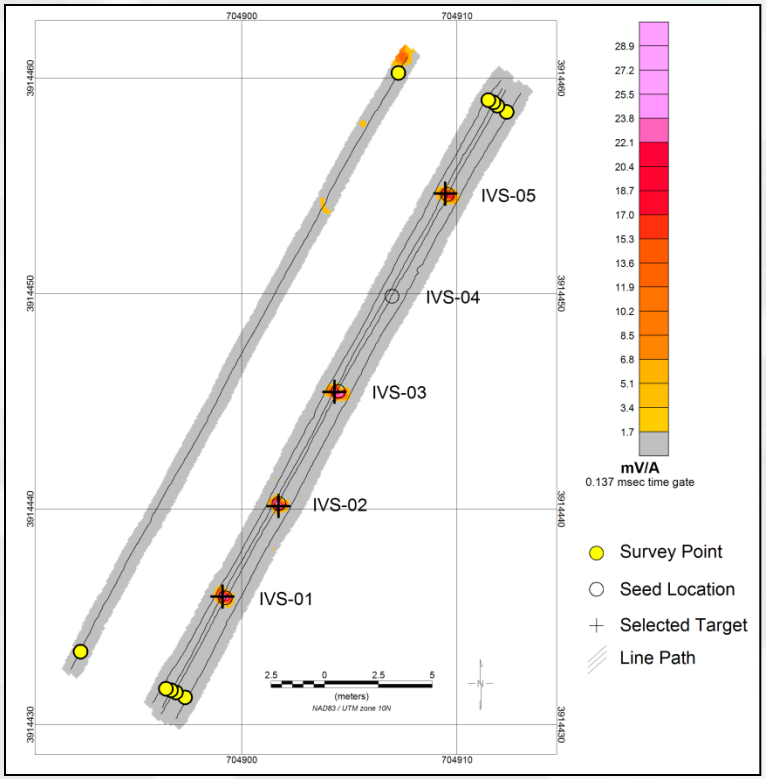
Classify Anomalies

Intrusive Investigation

Verification and Validation

Is the Sensor Functioning Properly and Ready to Collect Data?





IVS Tech Memo

TPP ➔ QAPP

Site Prep

Detection Survey

Cued Survey

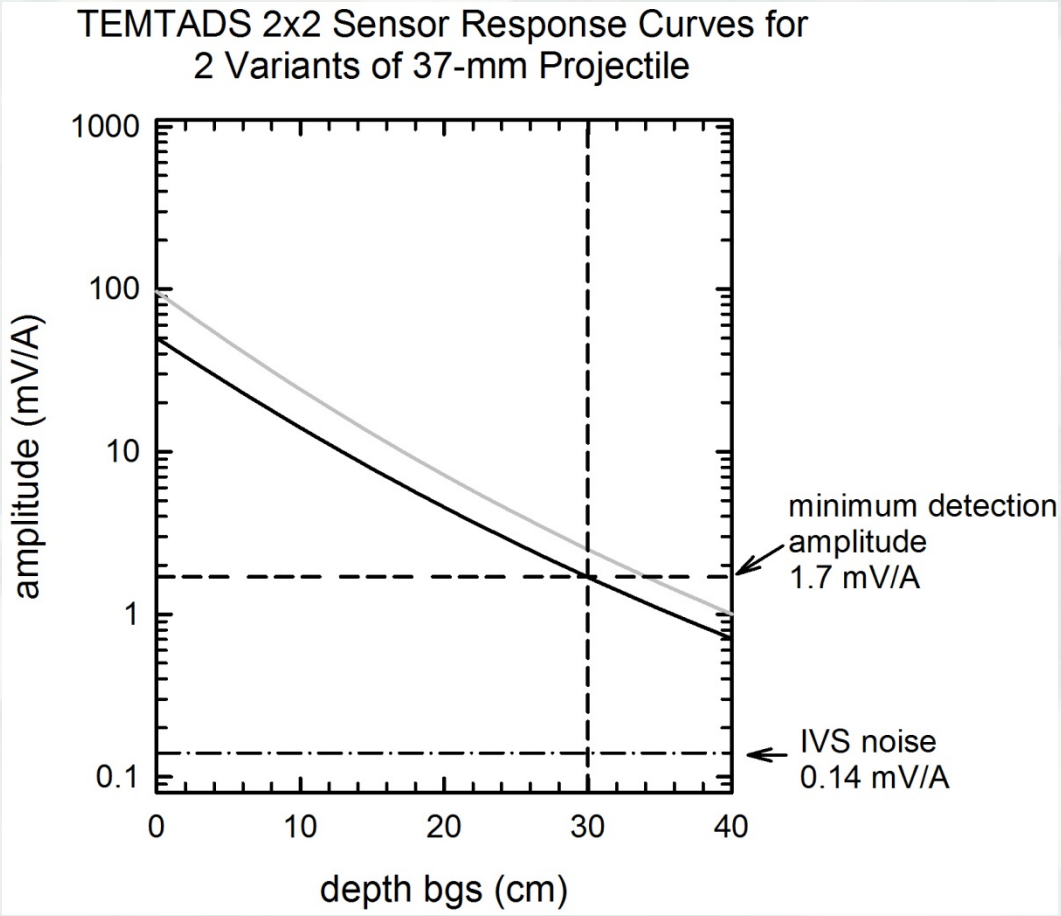
Classify Anomalies

Intrusive Investigation

Verification and Validation

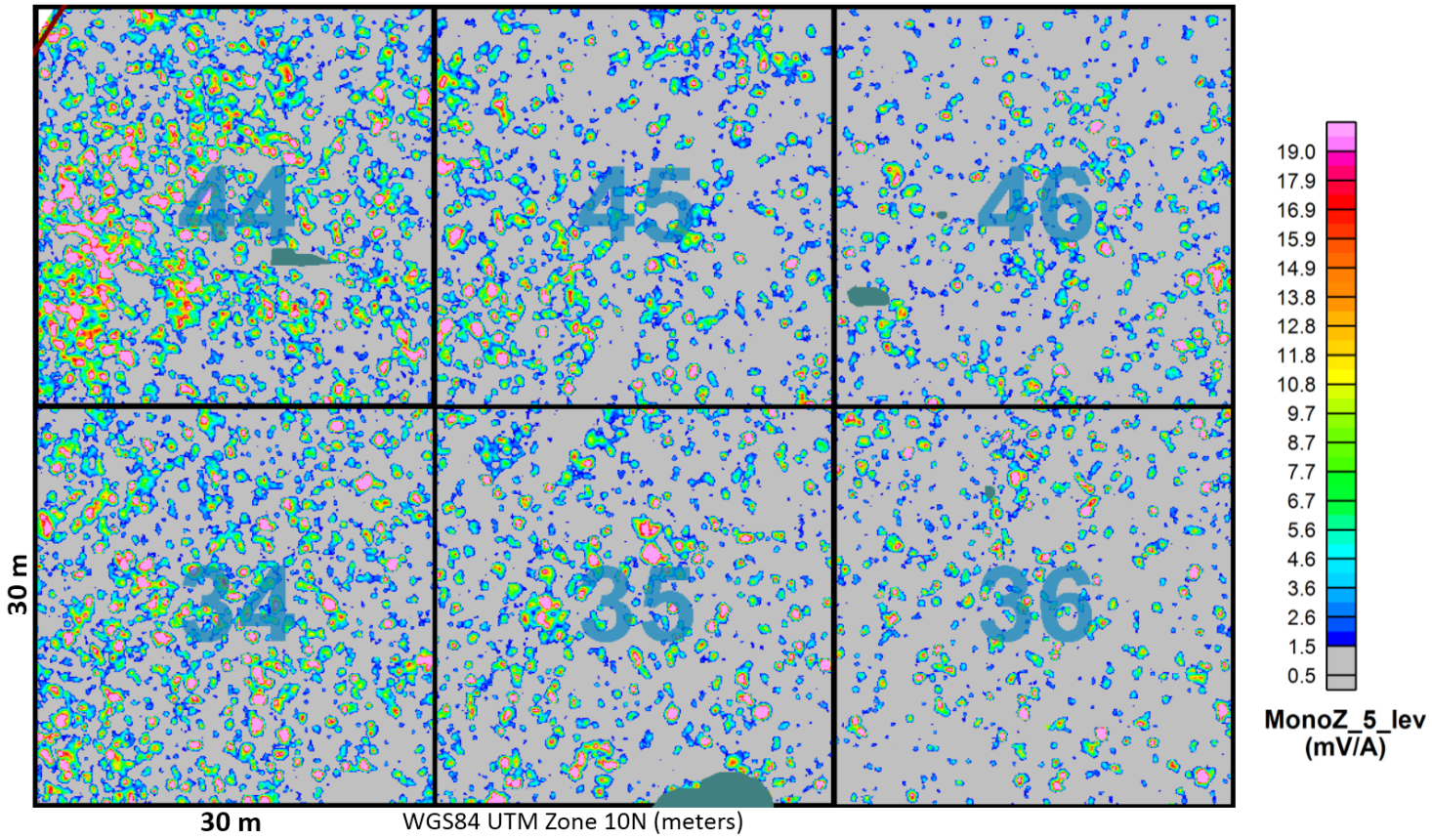
Are the Remedial Objectives Achievable?





Detection Survey

- TPP → QAPP
- Site Prep
- **Detection Survey**
- Cued Survey
- Classify Anomalies
- Intrusive Investigation
- Verification and Validation



Monostatic Z Component Response Amplitude

Anomaly Selection Methodology

- Amplitude Threshold
  - Small, near-surface frag results in amplitude equal to deeper targets of interest – lots of unnecessary “detections”
- Informed Source Selection
  - Use all channels of data collected from all receivers in analysis. Only flag anomalies that result from items big enough to be the smallest TOI (37-mm projectile in this case).

Anomaly Selection

TPP → QAPP

Site Prep

Detection Survey

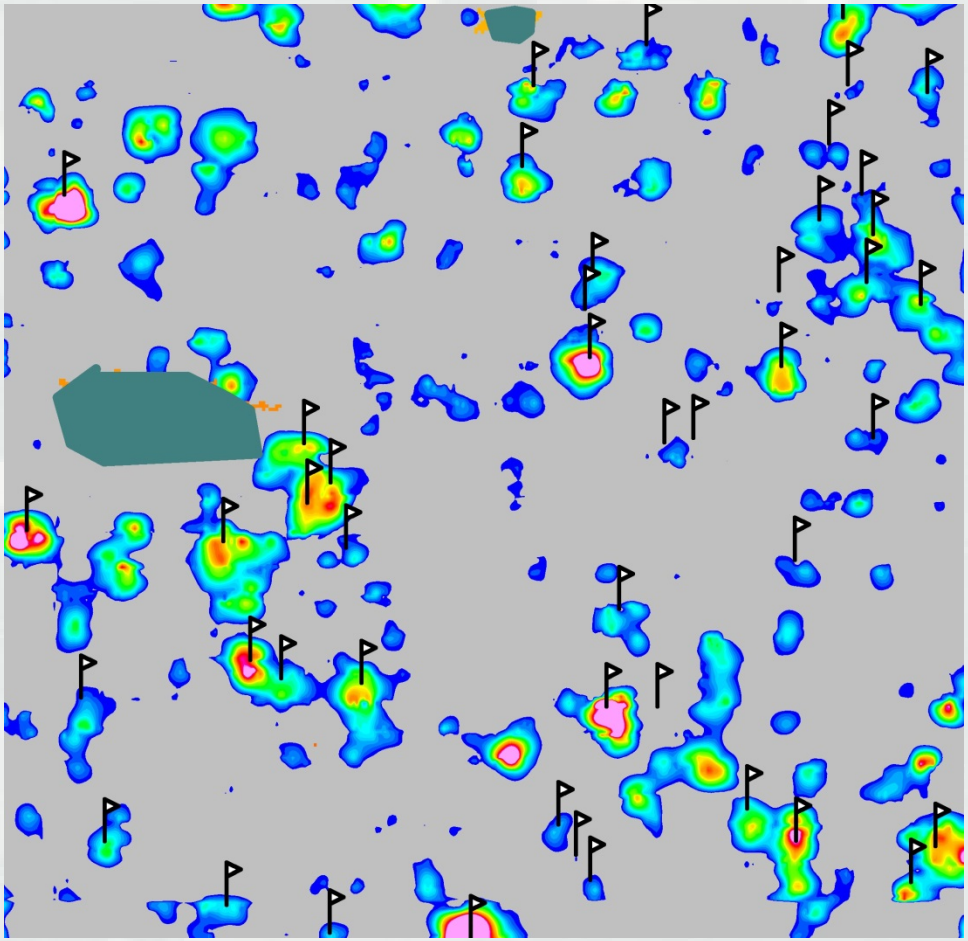
Cued Survey

Classify Anomalies

Intrusive Investigation

Verification and Validation

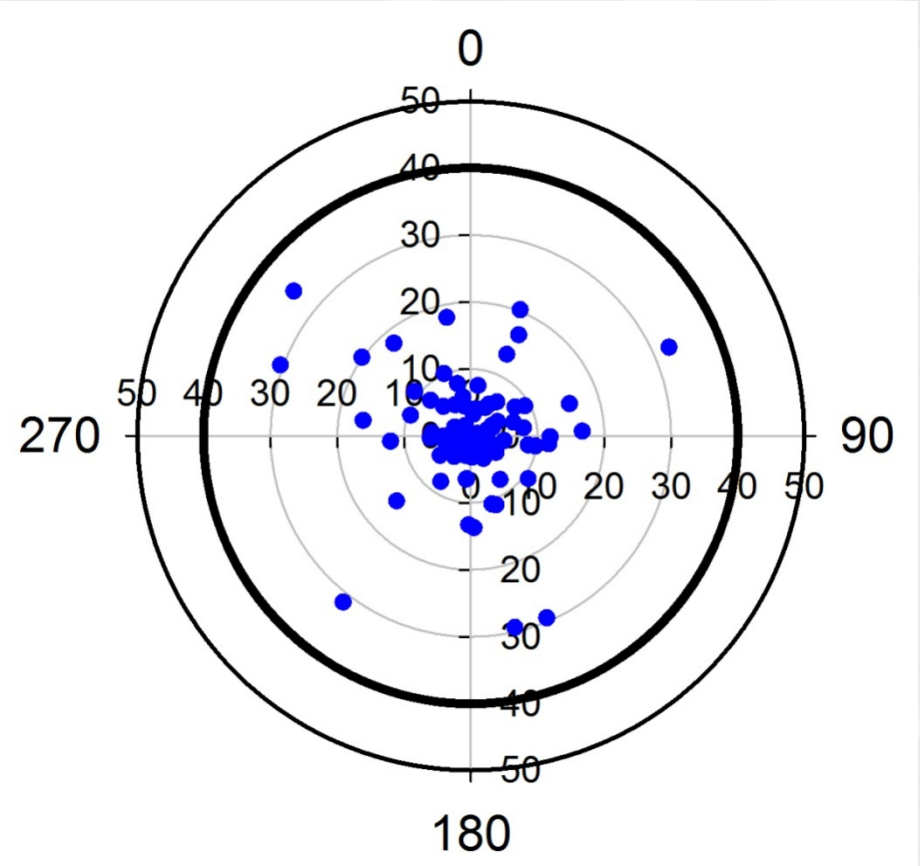
Advanced Anomaly Selection



Reduced detections by 50% on average

Detection of QC Seeds

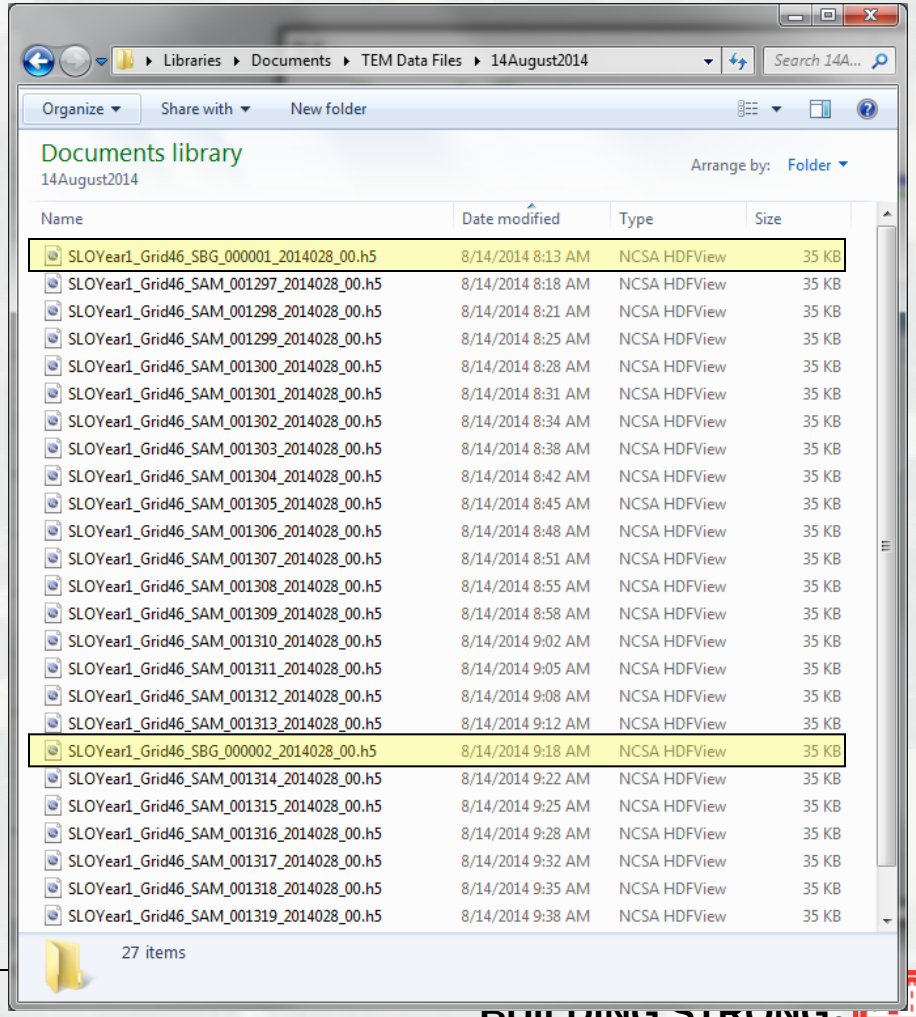
- TPP ➔ QAPP
- Site Prep
- **Detection Survey**
- Cued Survey
- Classify Anomalies
- Intrusive Investigation
- Verification and Validation



Cued Data

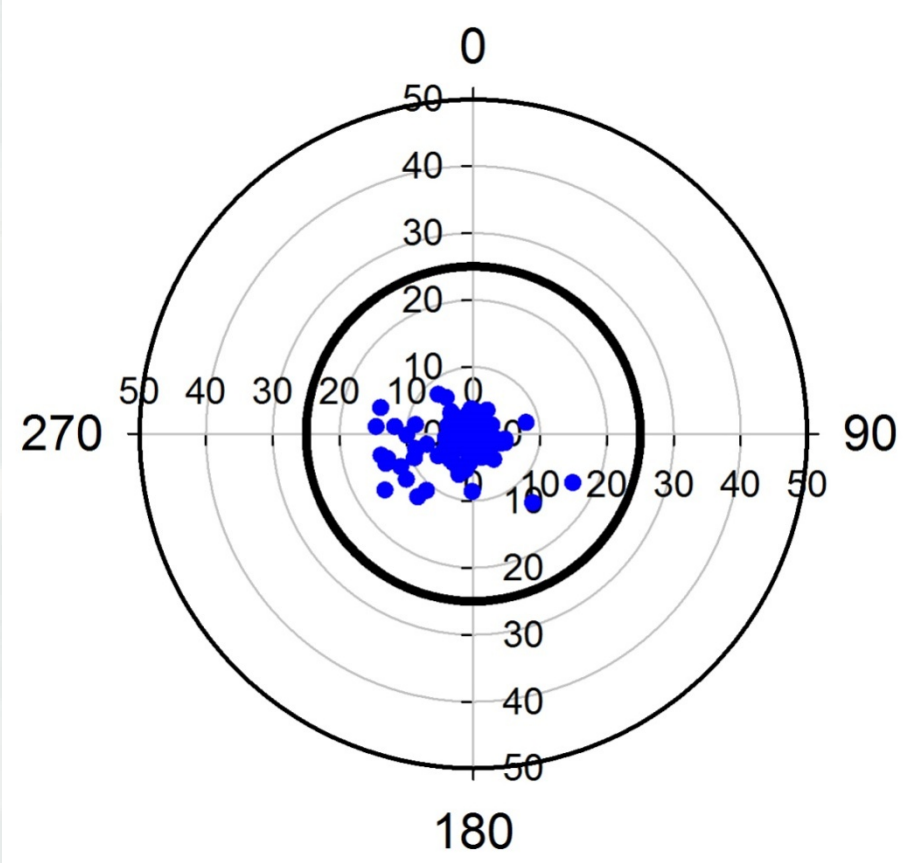
- TPP ➔ QAPP
- Site Prep
- Detection Survey
- **Cued Survey**
- Classify Anomalies
- Intrusive Investigation
- Verification and Validation





Government Evaluation of Validation Seed Locations after Inversions

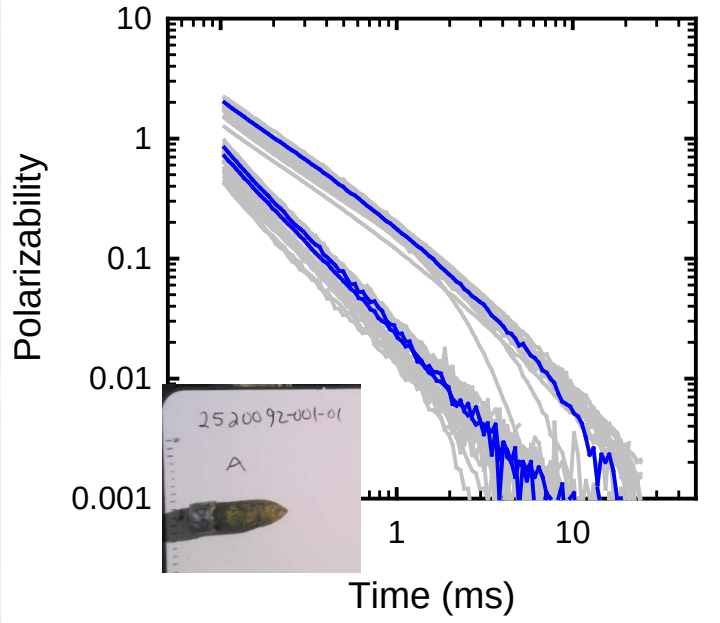
- TPP → QAPP
- Site Prep
- Detection Survey
- **Cued Survey**
- Classify Anomalies
- Intrusive Investigation
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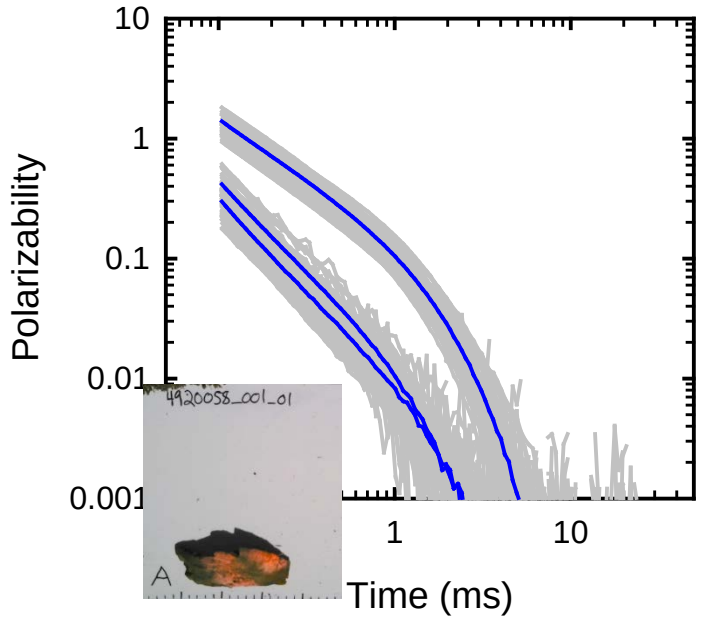
Identify Clusters

- TPP ➔ QAPP
- Site Prep
- Detection Survey
- Cued Survey
- **Classify Anomalies**
- Intrusive Investigation
- Verification and Validation

Cluster #2
(18 matches)



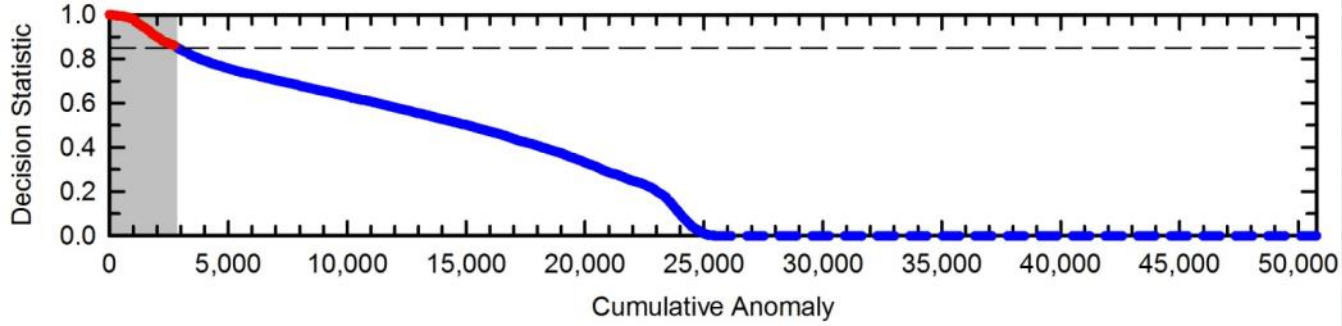
Cluster #3
(41 matches)

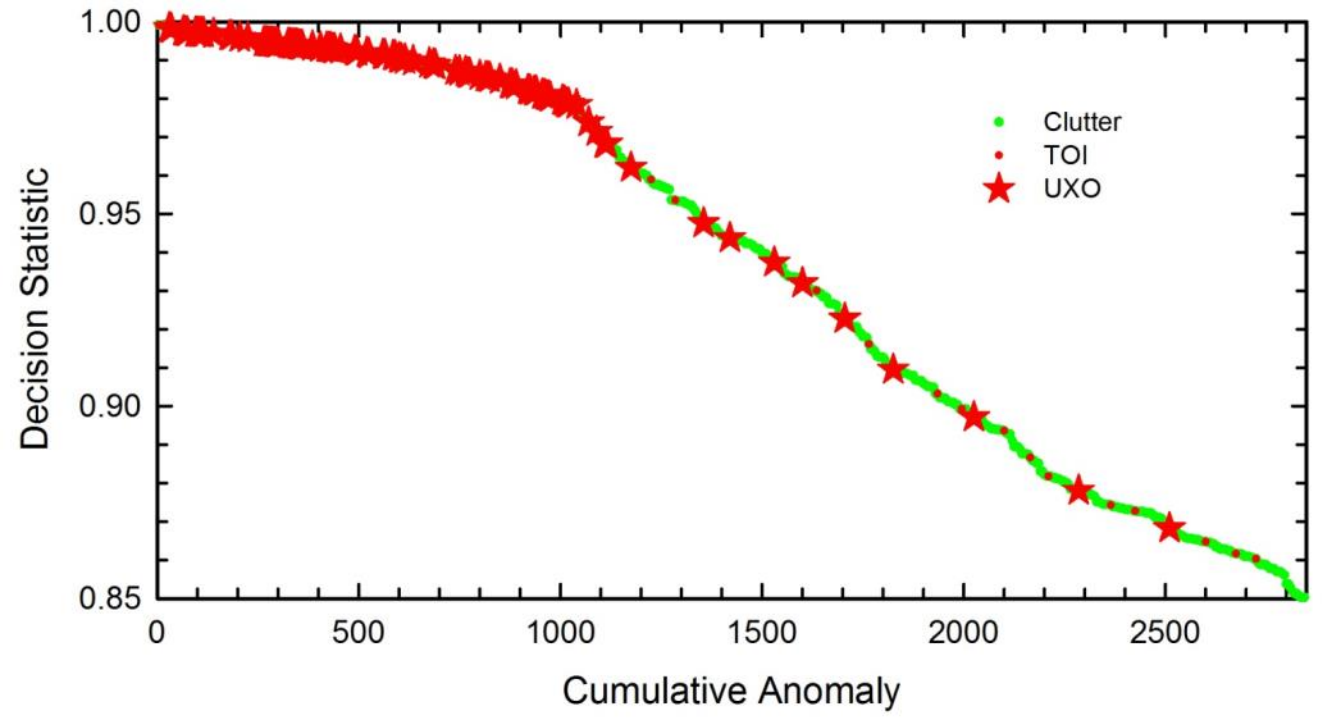


Cluster Match Threshold = 0.95

Intrusive Investigation

- TPP ➔ QAPP
- Site Prep
- Detection Survey
- Cued Survey
- Classify Anomalies
- **Intrusive Investigation**
- Verification and Validation

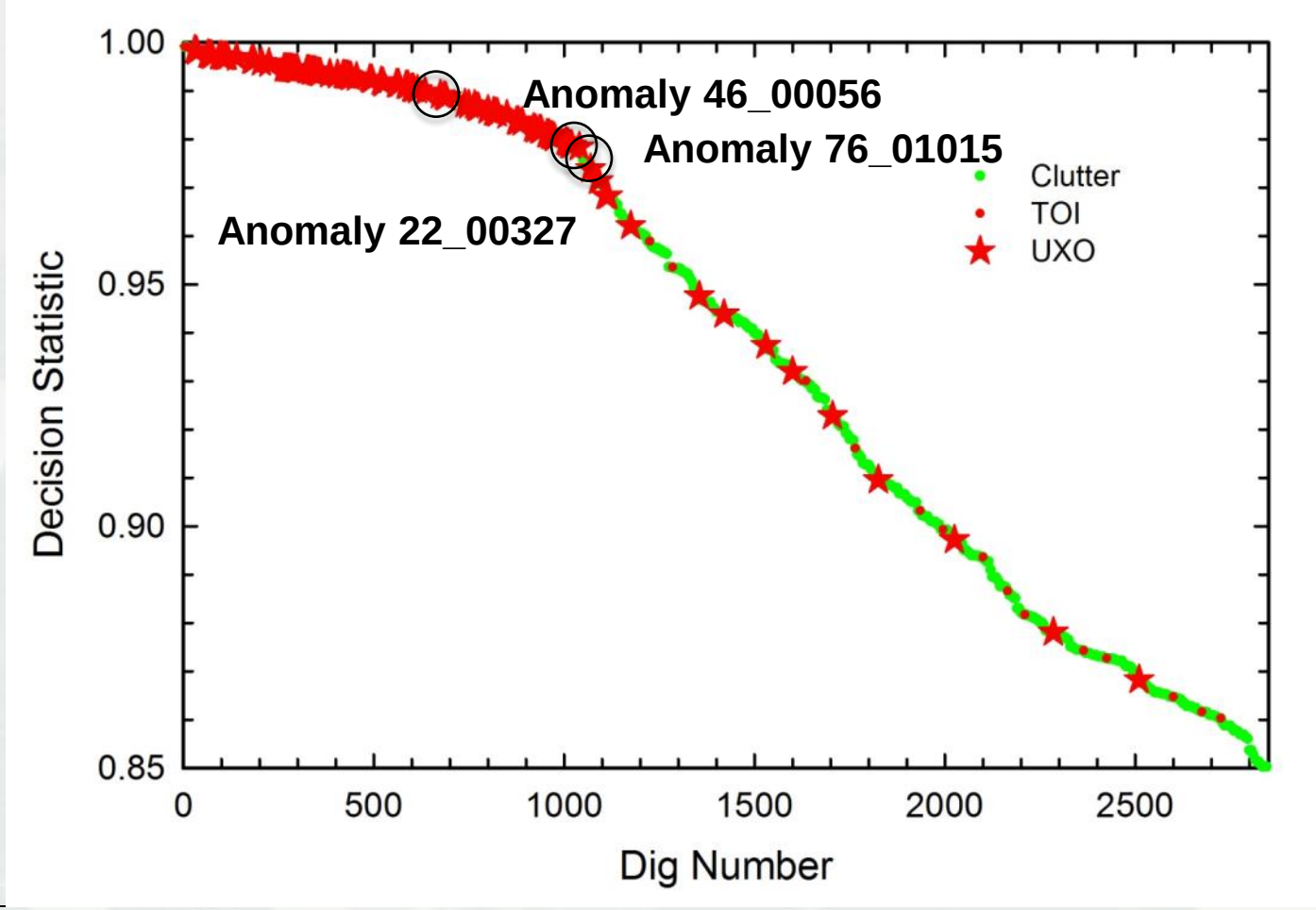




Intrusive Investigation Report

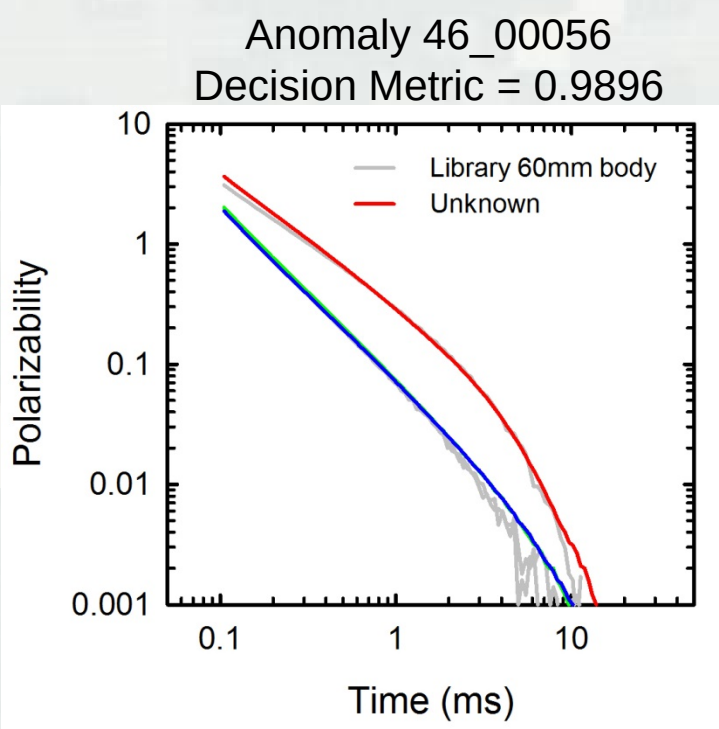
- TPP ➔ QAPP
- Site Prep
- Detection Survey
- Cued Survey
- Classify Anomalies
- **Intrusive Investigation**
- Verification and Validation

Were all recovered items consistent with analyst's predictions?



Intrusive Investigation Report

- TPP ➔ QAPP
- Site Prep
- Detection Survey
- Cued Survey
- Classify Anomalies
- **Intrusive Investigation**
- Verification and Validation

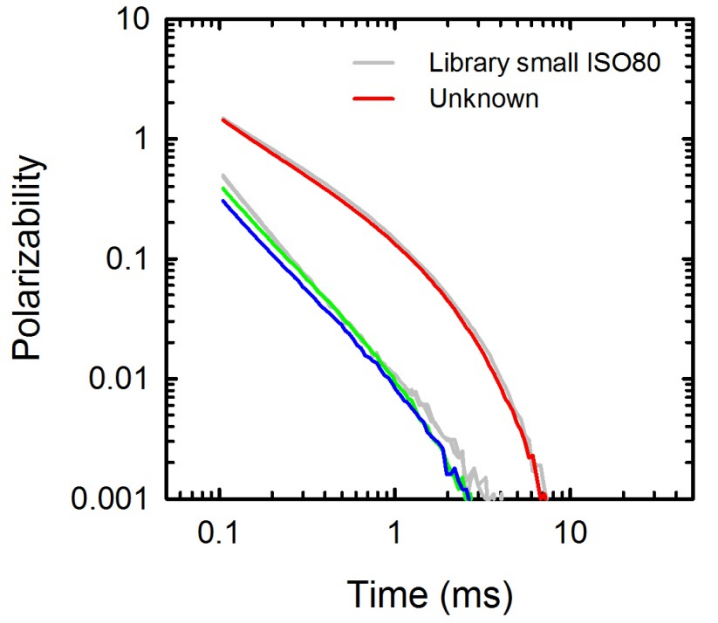




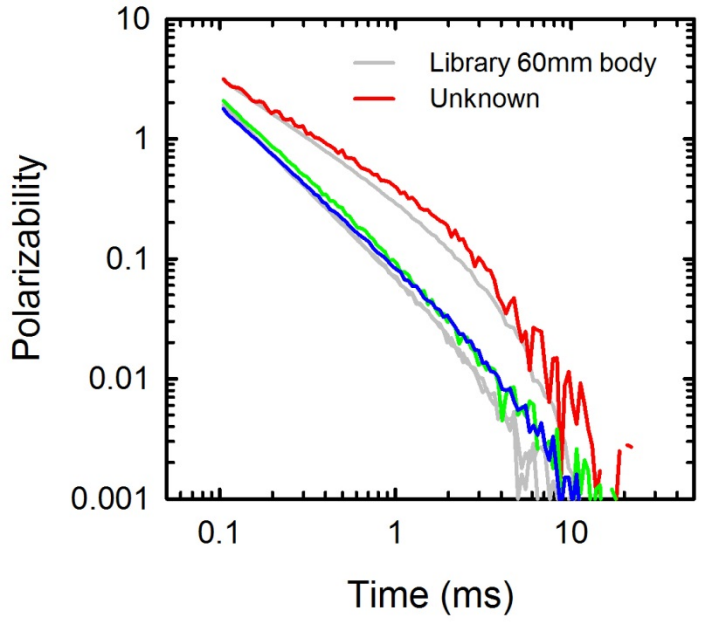
Intrusive Investigation Report

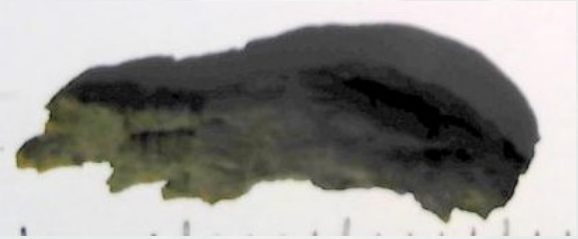
- TPP ➔ QAPP
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Anomaly 76_01015
Decision Metric = 0.9856



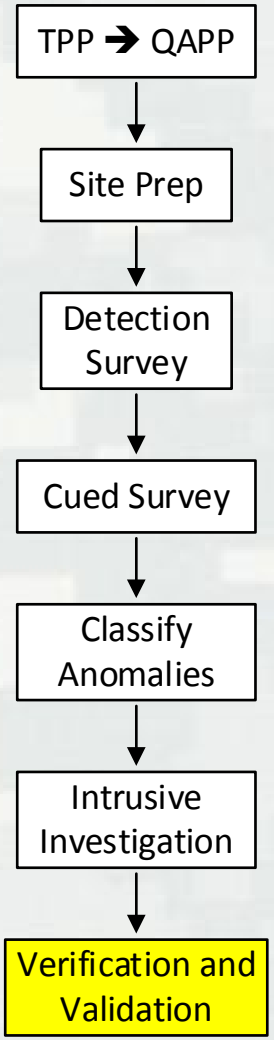
Anomaly 22_00327
Decision Metric = 0.9855







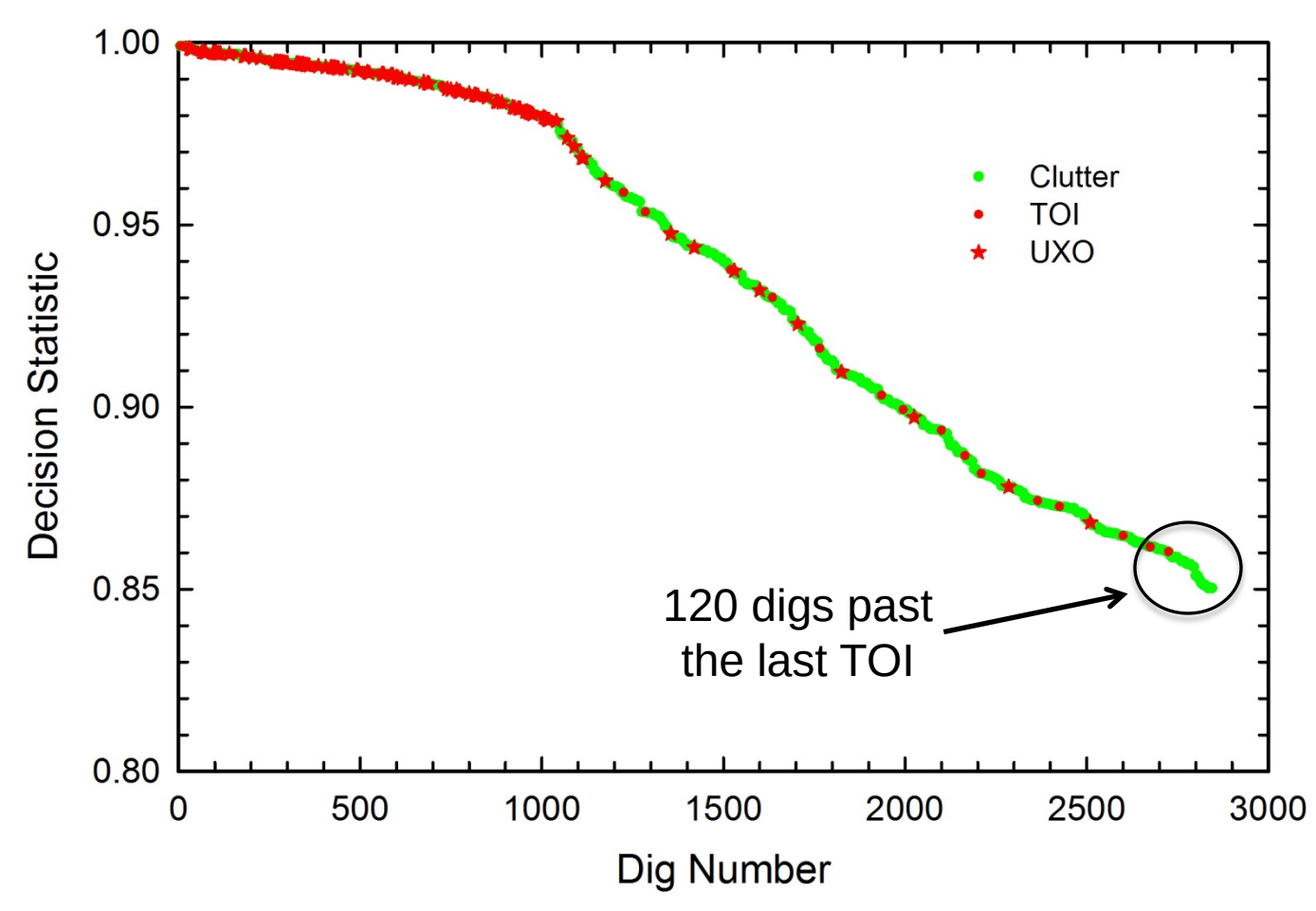
Verification and Validation



- Verify the stop-dig threshold
  - ▶ dig past the last TOI

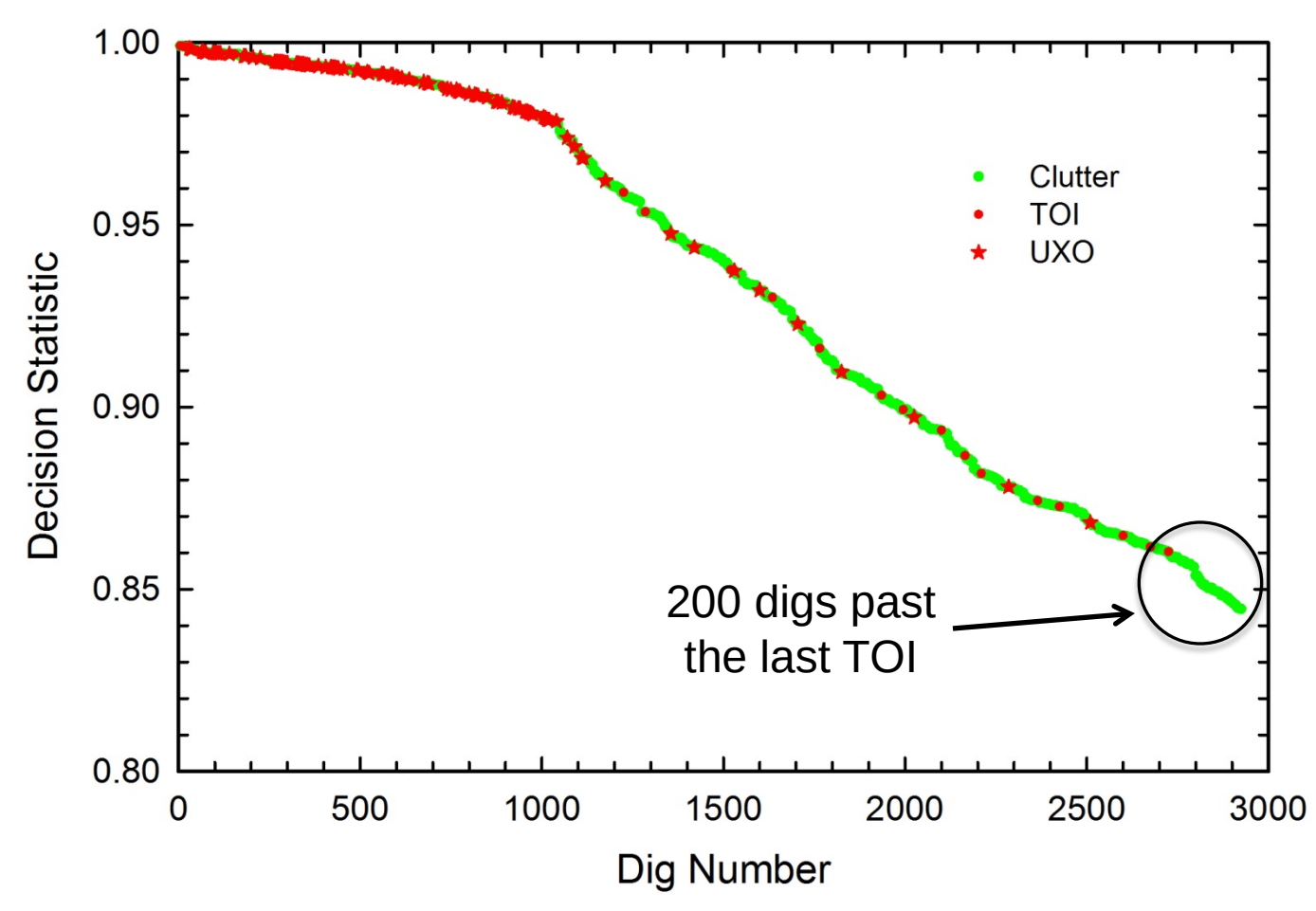
Contractor Stop Dig Point

- TPP → QAPP
- Site Prep
- Detection Survey
- Cued Survey
- Classify Anomalies
- Intrusive Investigation
- **Verification and Validation**

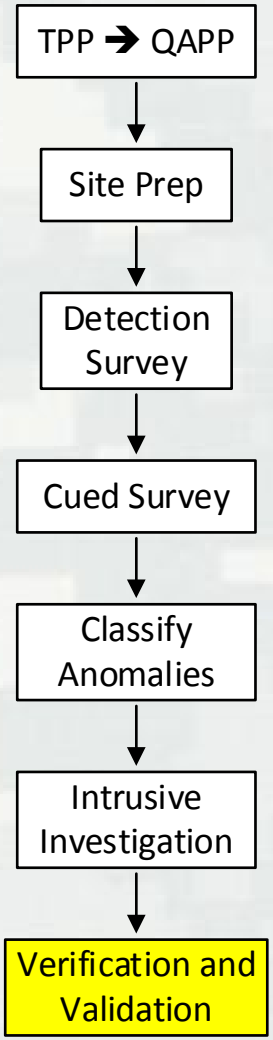


Verify The Threshold

- TPP → QAPP
- Site Prep
- Detection Survey
- Cued Survey
- Classify Anomalies
- Intrusive Investigation
- **Verification and Validation**



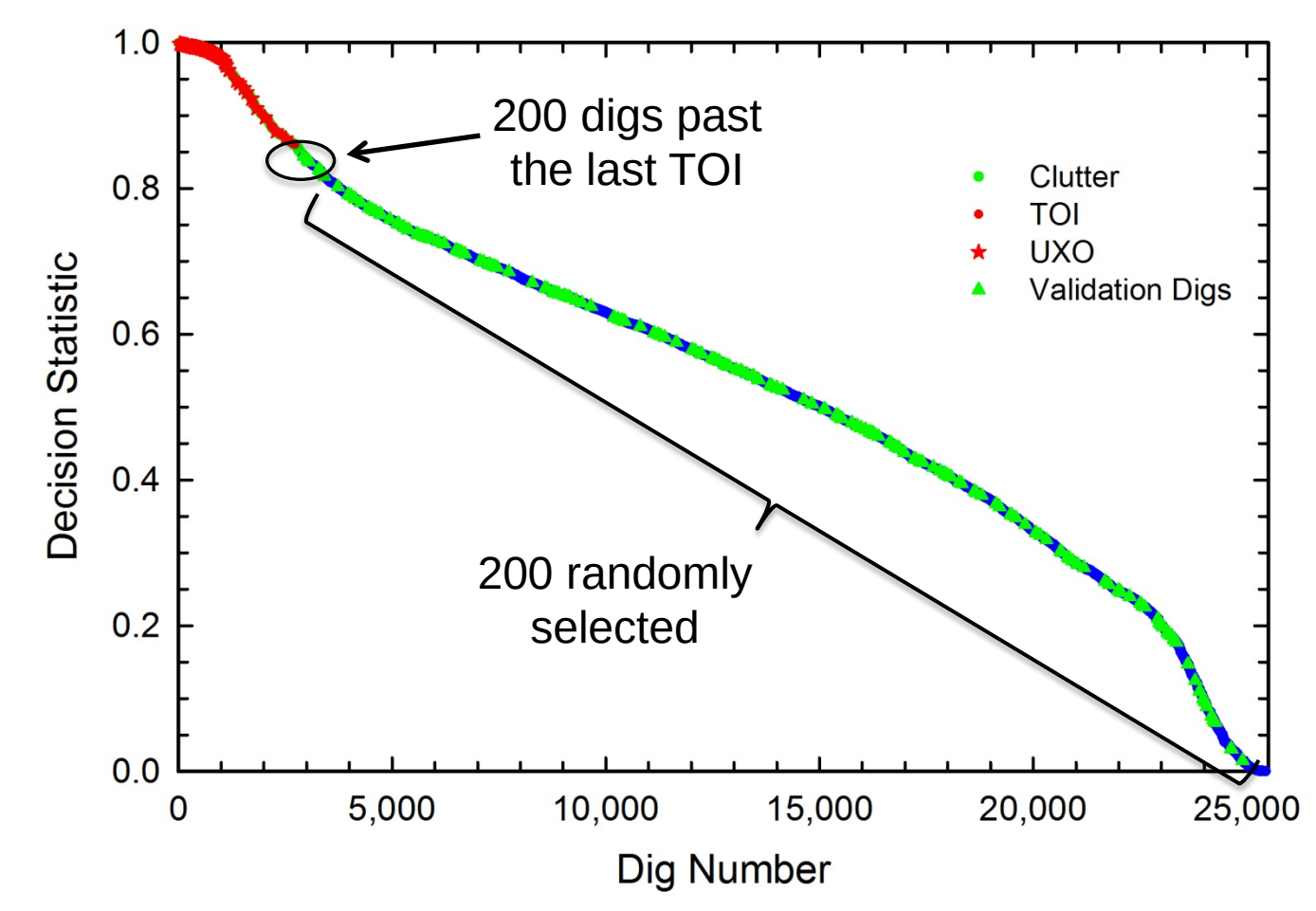
Verification and Validation



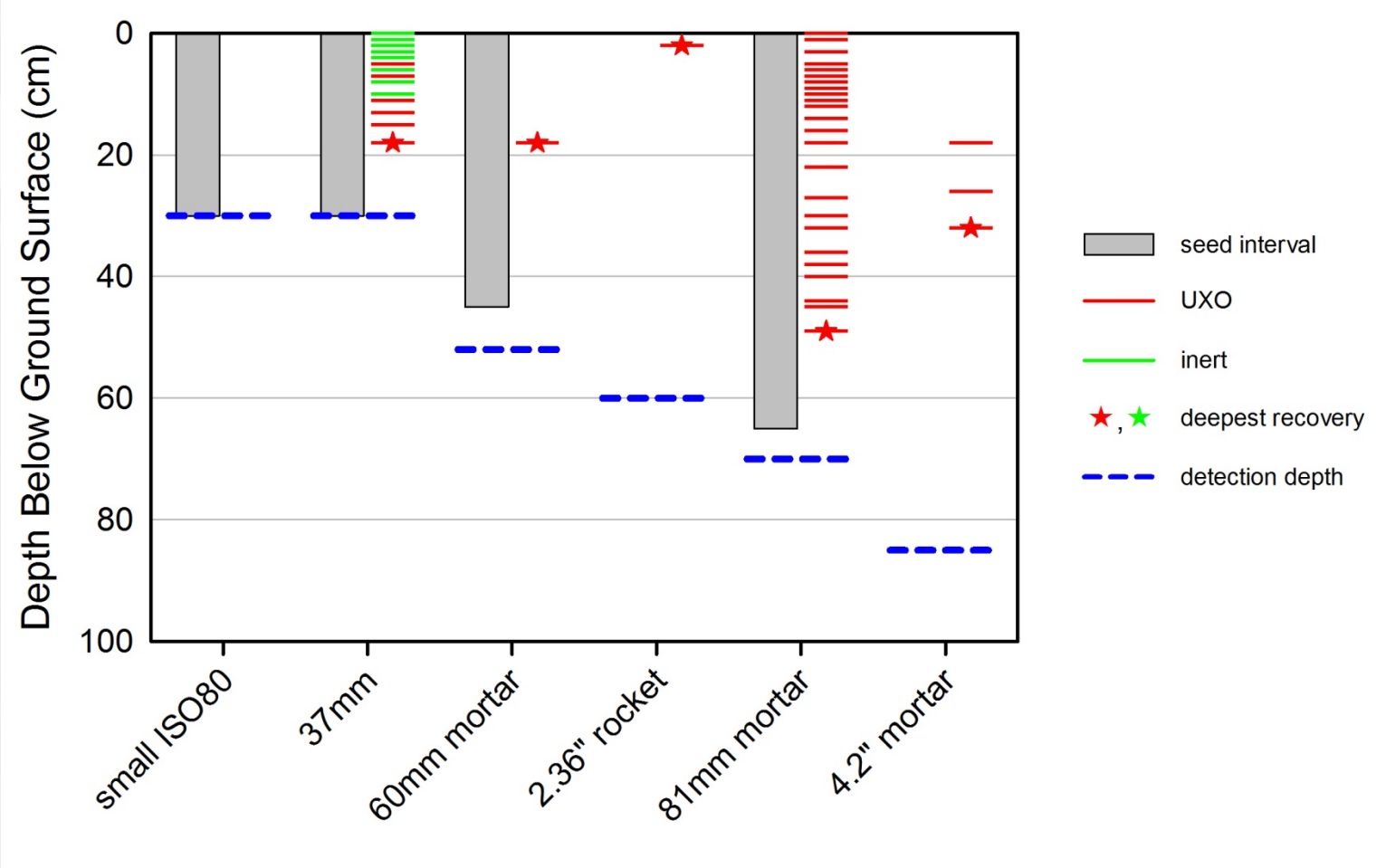
- Verify the stop-dig threshold
  - ►dig past the last TOI
- Validate the whole process
  - ►targeted investigation of items classified as likely clutter

Validate the Process

- TPP → QAPP
- Site Prep
- Detection Survey
- Cued Survey
- Classify Anomalies
- Intrusive Investigation
- **Verification and Validation**



After Action Vertical CSM



Everybody Is Happy Now!



Summary

Classification Basics – Summary

- Modern sensors →Reliable classification
- Analysis procedures →Extract intrinsic EMI signature
  - Depends only on size, shape and material properties of target
- Library-based classifiers→Reliably distinguish between munitions and clutter items
  - Match unknown targets with other objects with similar EMI signatures (i.e., things they “look like”)
  - Presumptive UXO (dig) if EMI “vision” is fuzzy or obscured

Where Do We Stand Today?

√ Commercially-available sensor

√ Available analysis tools

√ Trained contractor base

√ Trained Government geophysicists

√ Regulator and Stakeholder acceptance

~Government business practices

~Government PM acceptance

On-Going…

- Transfer of the technology to mainstream use
- Some of the challenges
  - ~~DoD explosive safety policies~~ complete
  - ~~equipment availability~~ complete
  - ~~contracting language and request for proposal requirements~~ complete
  - ~~quality control and quality assurance processes~~ complete
  - workforce/practitioner qualifications

Additional Training and Resources

- SERDP/ESTCP website contains webcasts, tutorials, and demonstration reports on the classification technology
  - www.serdp-estcp.org
- ESTCP Technology Transfer Workshops (June 6-7 2012 & June 10-11 2015 Golden, Colorado)
  - Results of site demonstrations, outdoor technology demonstrations, tutorials, and software
- M2S2 Webinar Series
  - http://www.clu-in.org/conf/tio/m2s2fy15-2_022615/
  - http://www.clu-in.org/conf/tio/m2s2fy14-3_022514/
  - http://www.clu-in.org/conf/tio/m2s2-3_042213/
- Interstate Technology Regulator Council

  Geophysical Classification For Munitions Response: http://www.itrcweb.org/gcmr-2/

  Archived web training: https://clu-in.org/conf/itrc/GCMR_011416/



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Army UXO Safety Program





THE VERTICAL CONCEPTUAL SITE MODEL, AND VISUAL SAMPLE PLAN

Advanced Geophysical Classification (AGC)

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CONCEPTUAL SITE MODELS

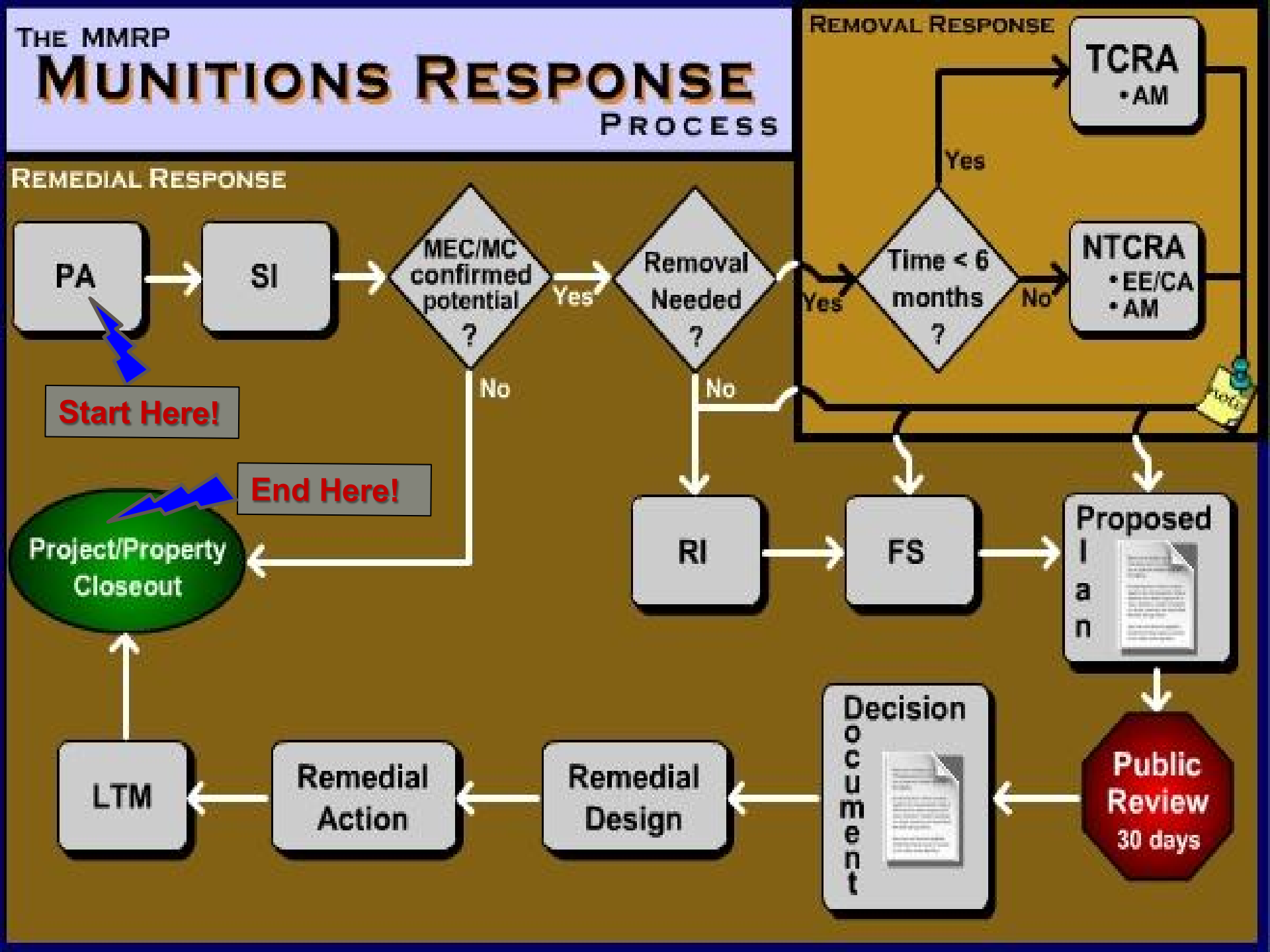
IN THE BEGINNING…

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THE MMRP

MUNITIONS RESPONSE PROCESS



PRELIMINARY ASSESSMENT: FURTHER RESPONSE NEEDED →THE INITIAL CSM



Areas suspected to contain MEC...

Now What?

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SI: PRESENCE OR ABSENCE?



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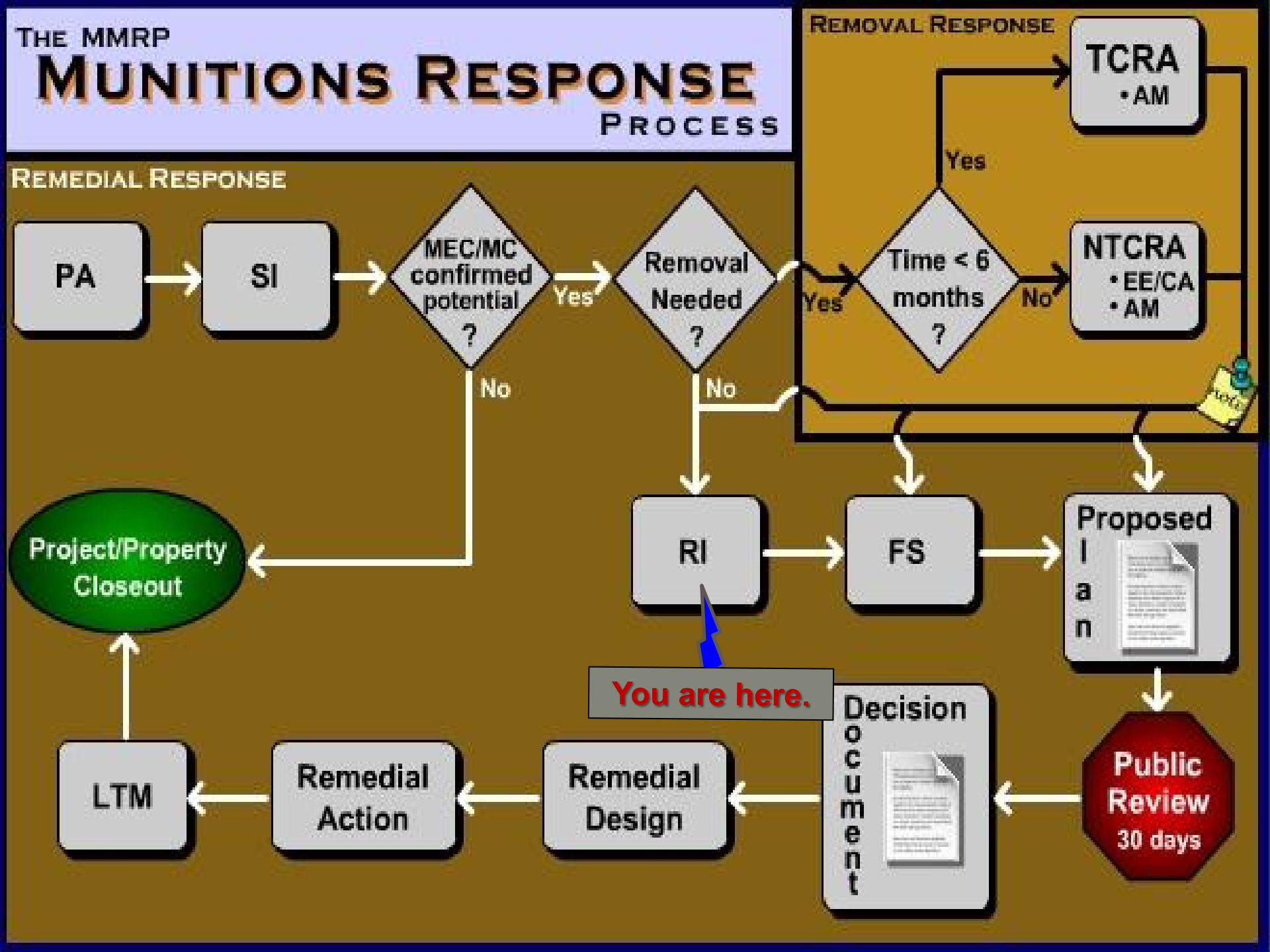
REMOVAL ACTIONS – MIGHT BE NEEDED SOMETIMES



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The MMRP Munitions Response Process



PURPOSE FOR THE RI

To investigate the project area to define nature and extent of release, and determination of "acceptable versus unacceptable" risk to support a recommendation for one of the following:

- No action is appropriate (Acceptable/Protective)
- Conduct Feasibility Study (Unacceptable/not Protective)
- Collect additional data via an "expanded" RI (Inconclusive Protectiveness / Characterization)

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EPA RI/FS GUIDANCE

"The objective of the RI/FS process is not the unobtainable goal of removing all uncertainty, but rather to gather information sufficient to support an informed risk management decision regarding which remedy appears to be most appropriate for a given site."

[1] Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, U.S. EPA, October 1988

Note that the Remedial Investigation and Feasibility Study (RI/FS) share the same objective.

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UPDATED CSM

The post-RI CSM forms the basis for the Remedial Design, to include Advanced Geophysical Classification.

- What is the unacceptable risk?
- What will we look for?
- Where will we look?
- To what depth?
- What is the Remedial Action Objective?

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BASELINE RISK ASSESSMENT

The baseline risk assessment should demonstrate whether there is unacceptable risk associated with DoD releases.

- Toxicity and concentration of contaminants
- Fate and transport of contaminants
- Current and potential future land use
- Current and potential receptors (human and ecological)

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CONCEPTUAL SITE MODELS

CONCEPTUAL SITE MODEL (CSM)

Basic understanding of what is going on.

- Where MEC is expected
- Identifies receptors
- Describes exposure scenarios (land use)

Forms basis for communication with stakeholders.

Assists in developing investigation strategy and DQOs.

A CSM is a **model** that illustrates what we know and suspect is going on at an MRS.

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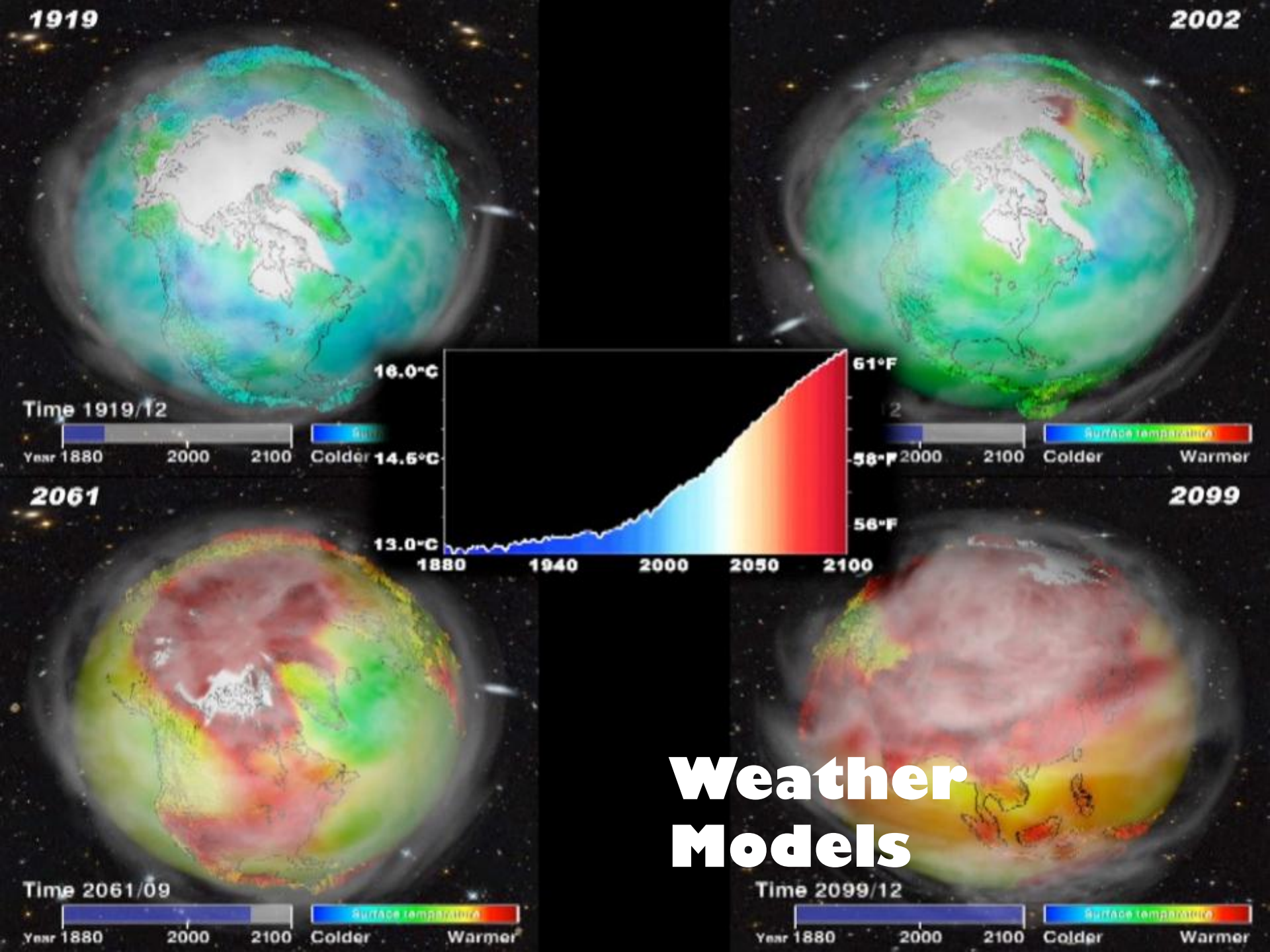
Let’s look at some different types of **models…**

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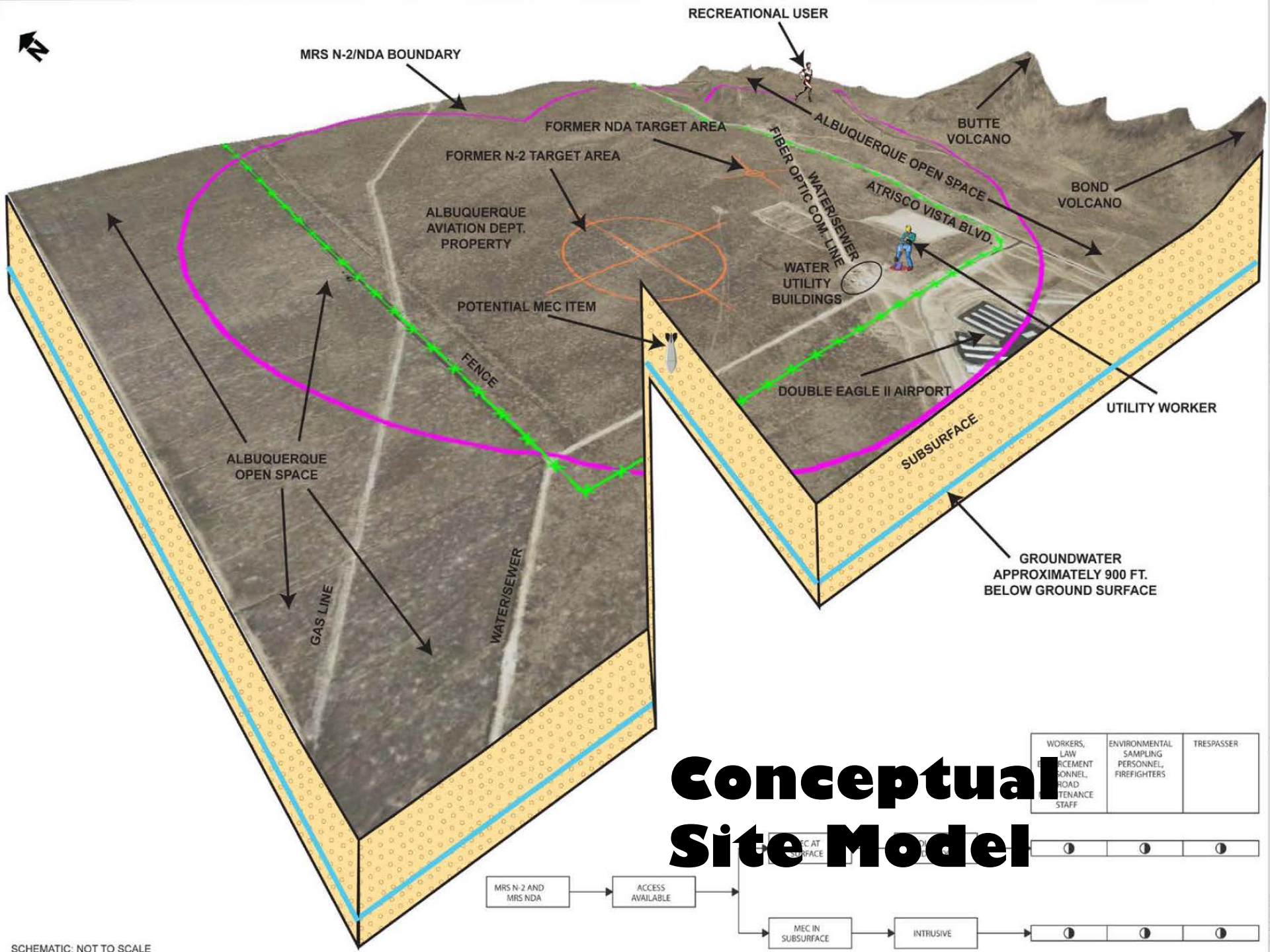
Model Trains


1919
2002
16.0°C
14.5°C
13.0°C
61°F
58°F
56°F
1880
1940
2000
2050
2100
Time 1919/12
Year 1880
2000
2100
Colder
Warmer
2061
2099
Time 2061/09
Time 2099/12
Weather
Models

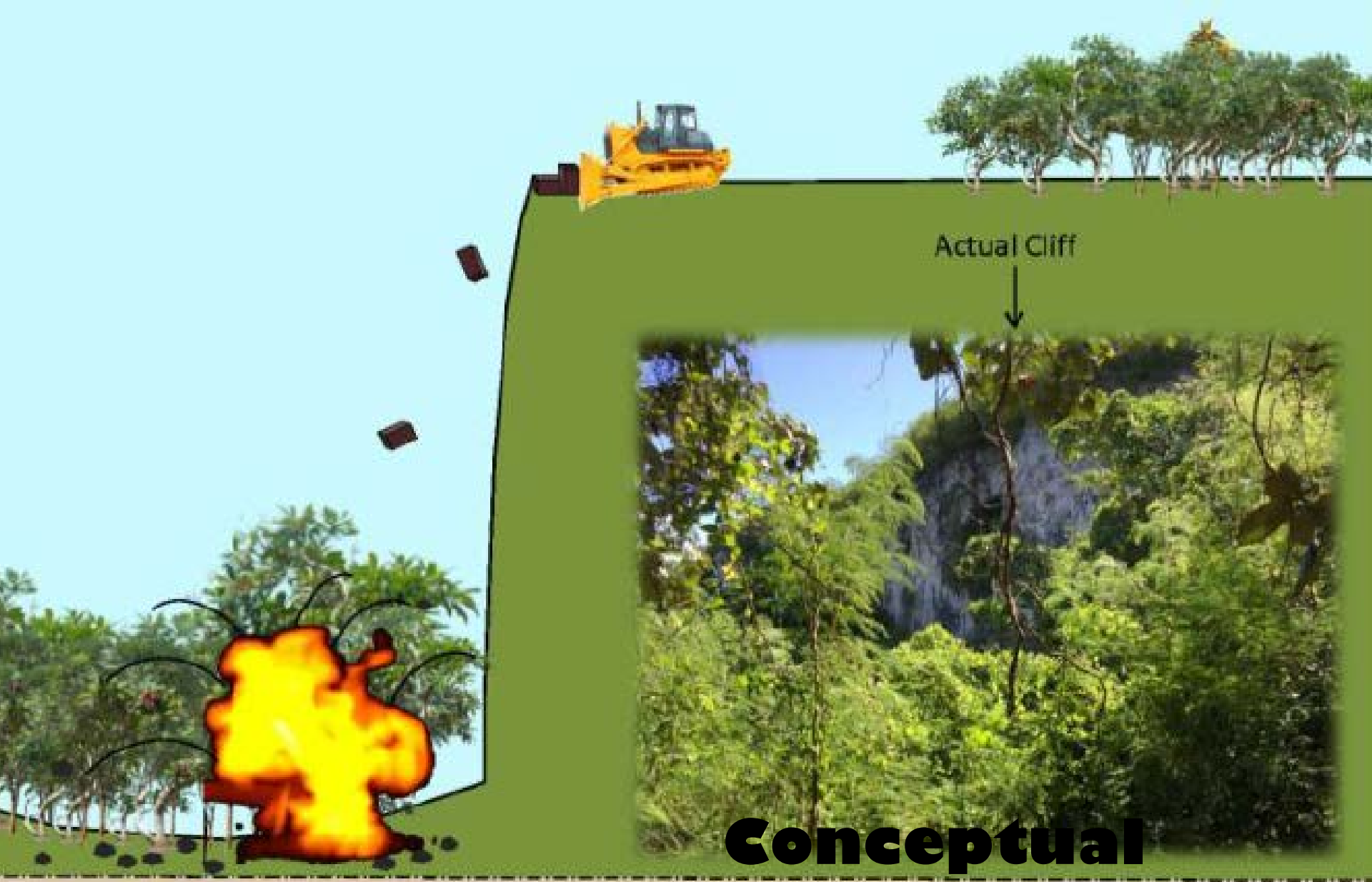

Model Volcano



Mississippi River Model



Conceptual Site Model



Conceptual Site Model

Leaching to soil

*MC potentially includes metals, PAHs, and explosives

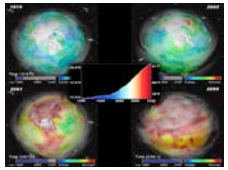


Boom.

QUIZ!

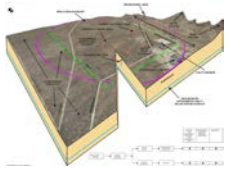
Of the seven preceding models, which TWO have been used in FUDS MMRP reports?











✓



✓



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INITIAL CSM

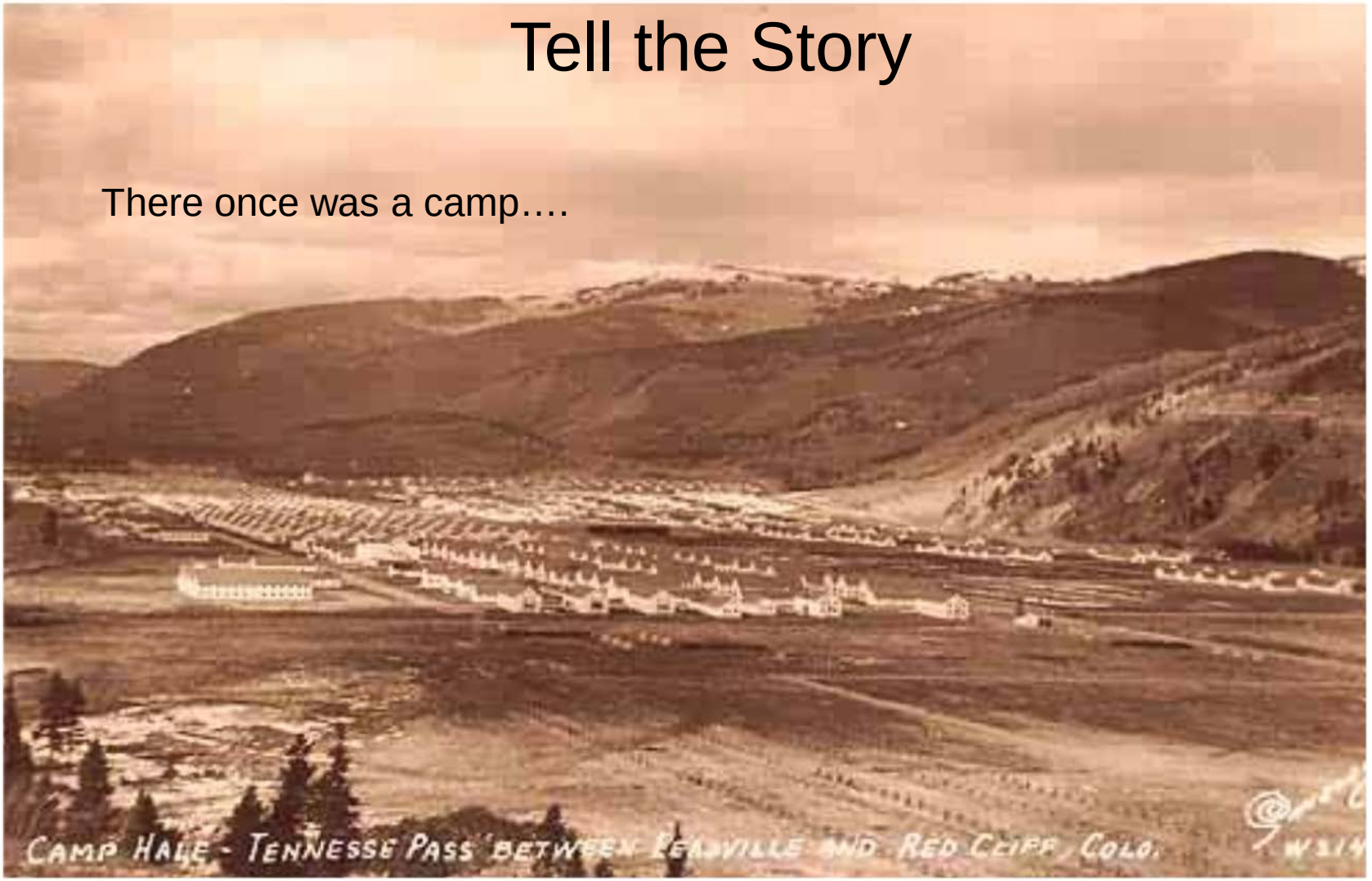


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Tell the Story

There once was a camp….



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CSM

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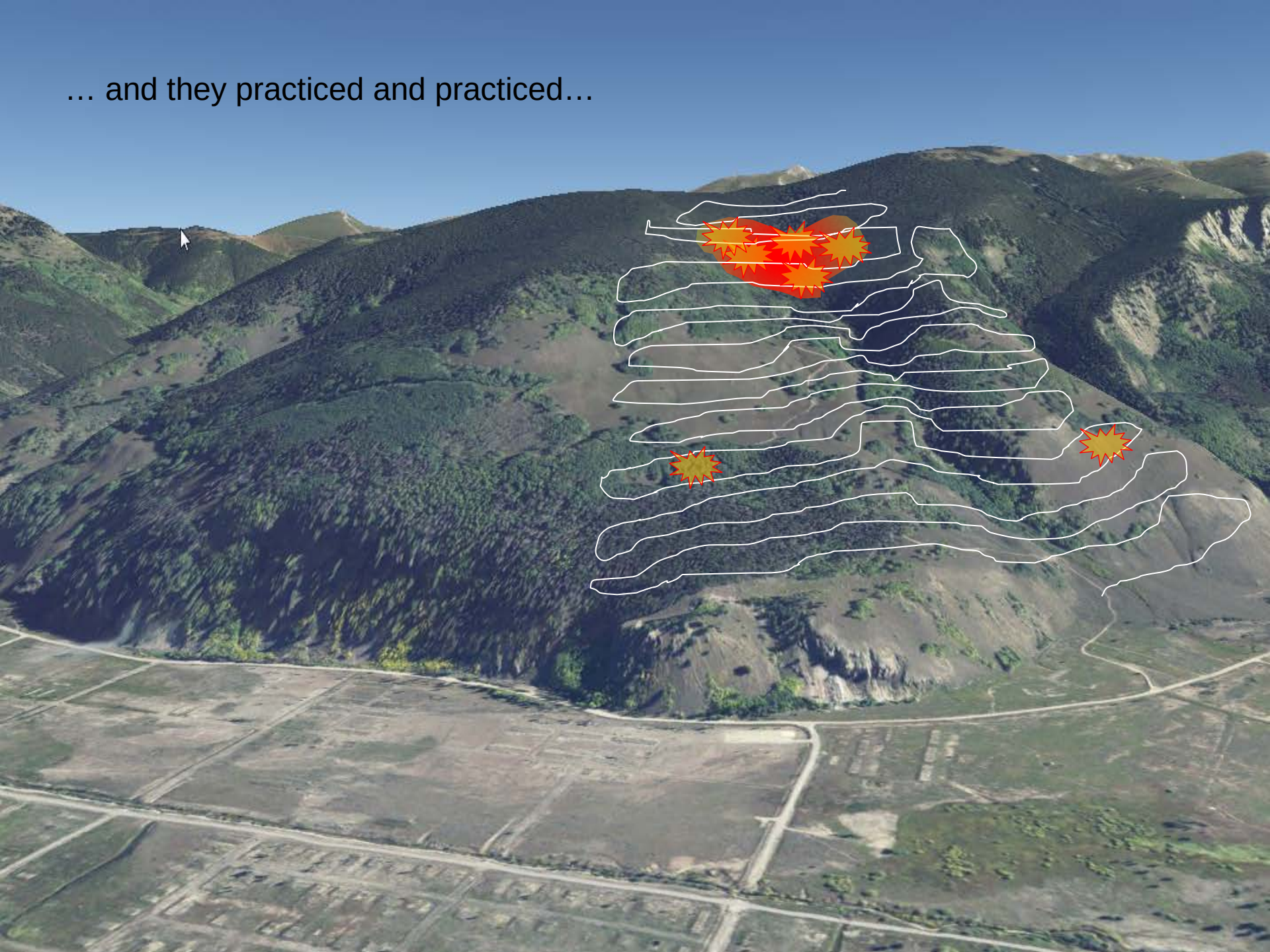
They REALLY used it….blew some stuff up.



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… and they practiced and practiced…



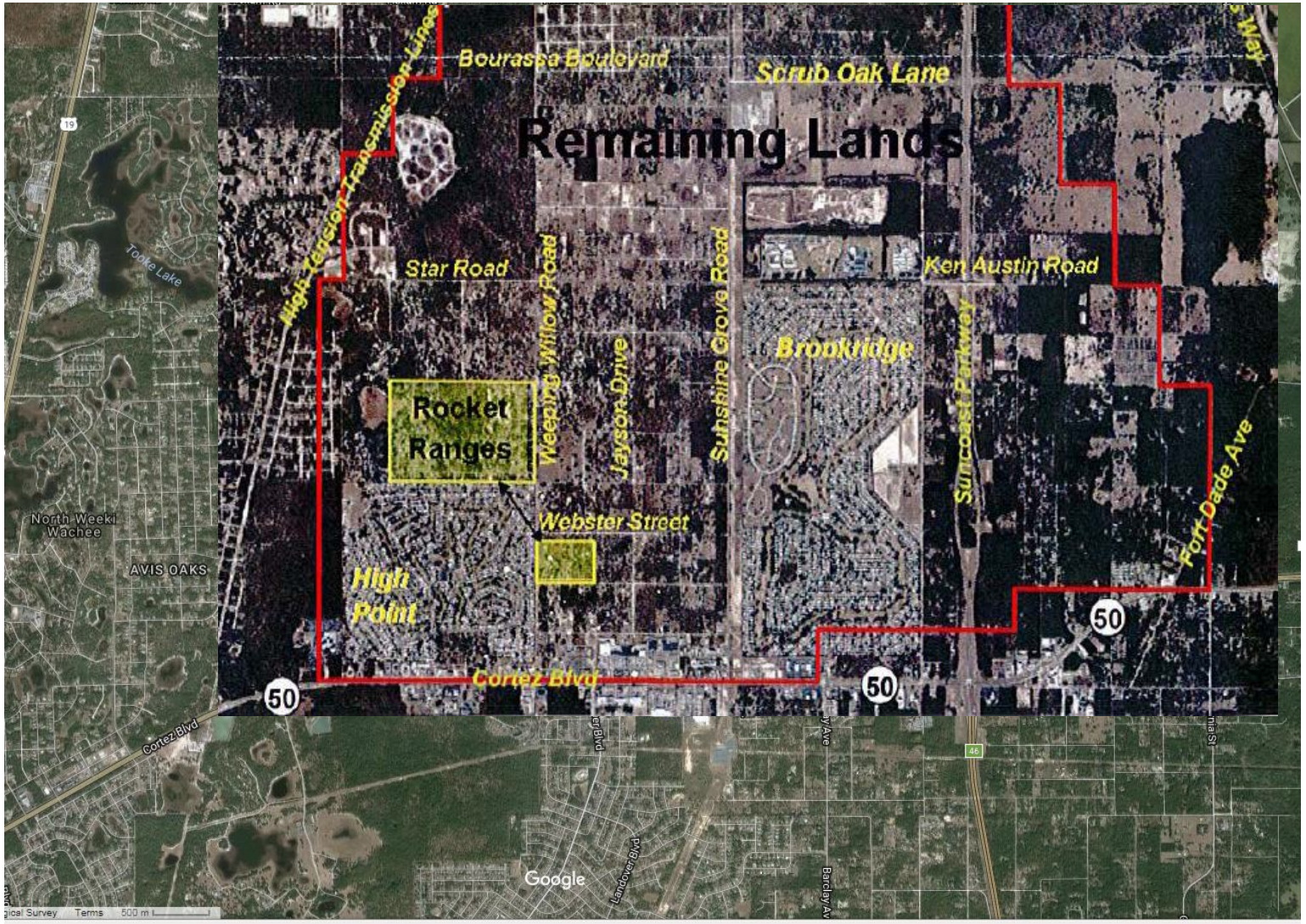
… and they left some stuff behind



LAND USE: WHY WE NEED TO KNOW



LAND USE

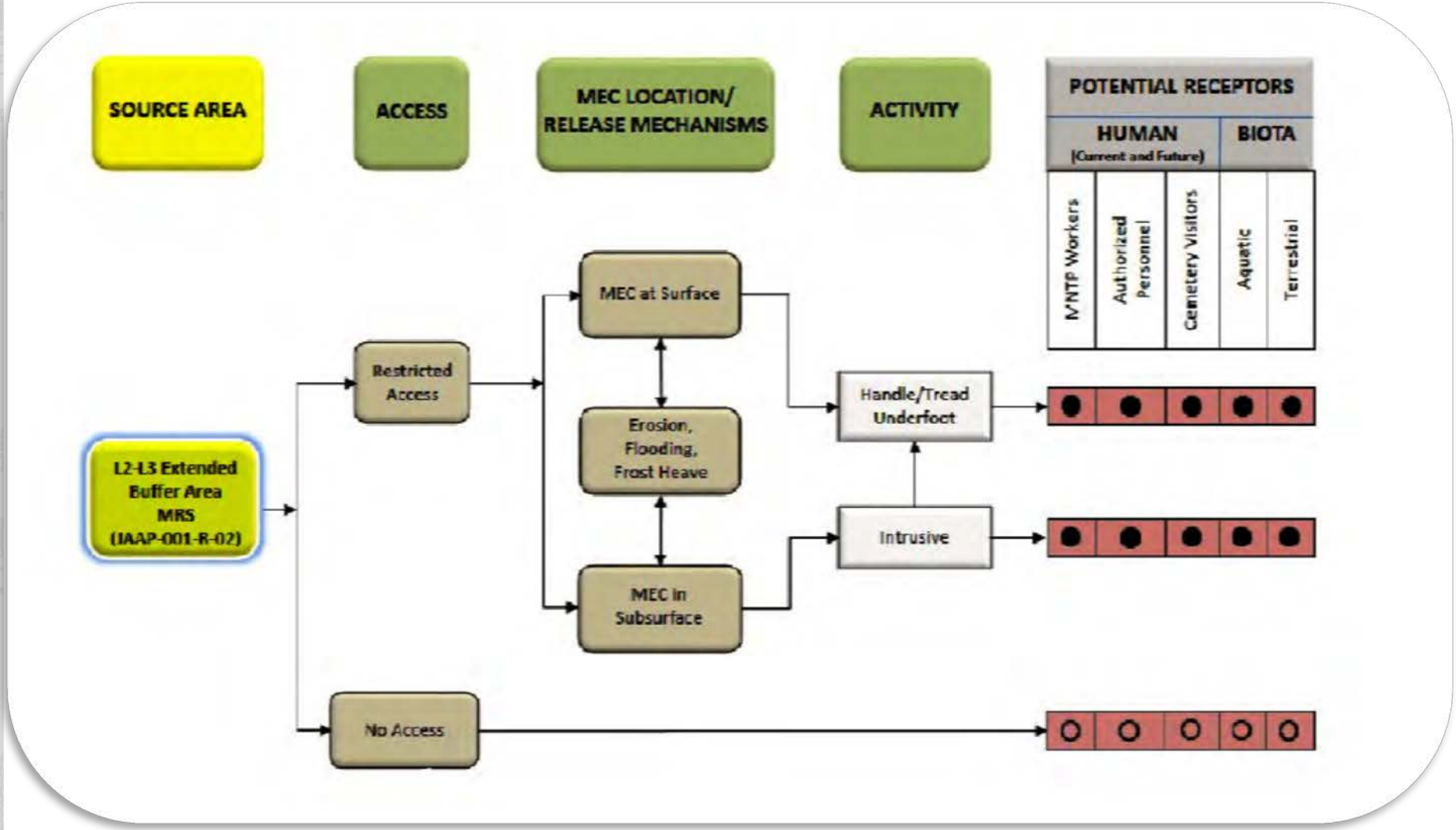

Remaining Lands
Bourassa Boulevard
Scrub Oak Lane
High Tension Transmission Lines
Star Road
Ken Austin Road
Weeping Willow Road
Jaysor Drive
Sunshine Grove Road
Brooktidge
Suncoast Parkway
Fort Dade Ave
Rocket Ranges
Webster Street
High Point
Cortez Blvd
50
Tooke Lake
North Weeki Wachee
AVIS OAKS
Google

LAND USE









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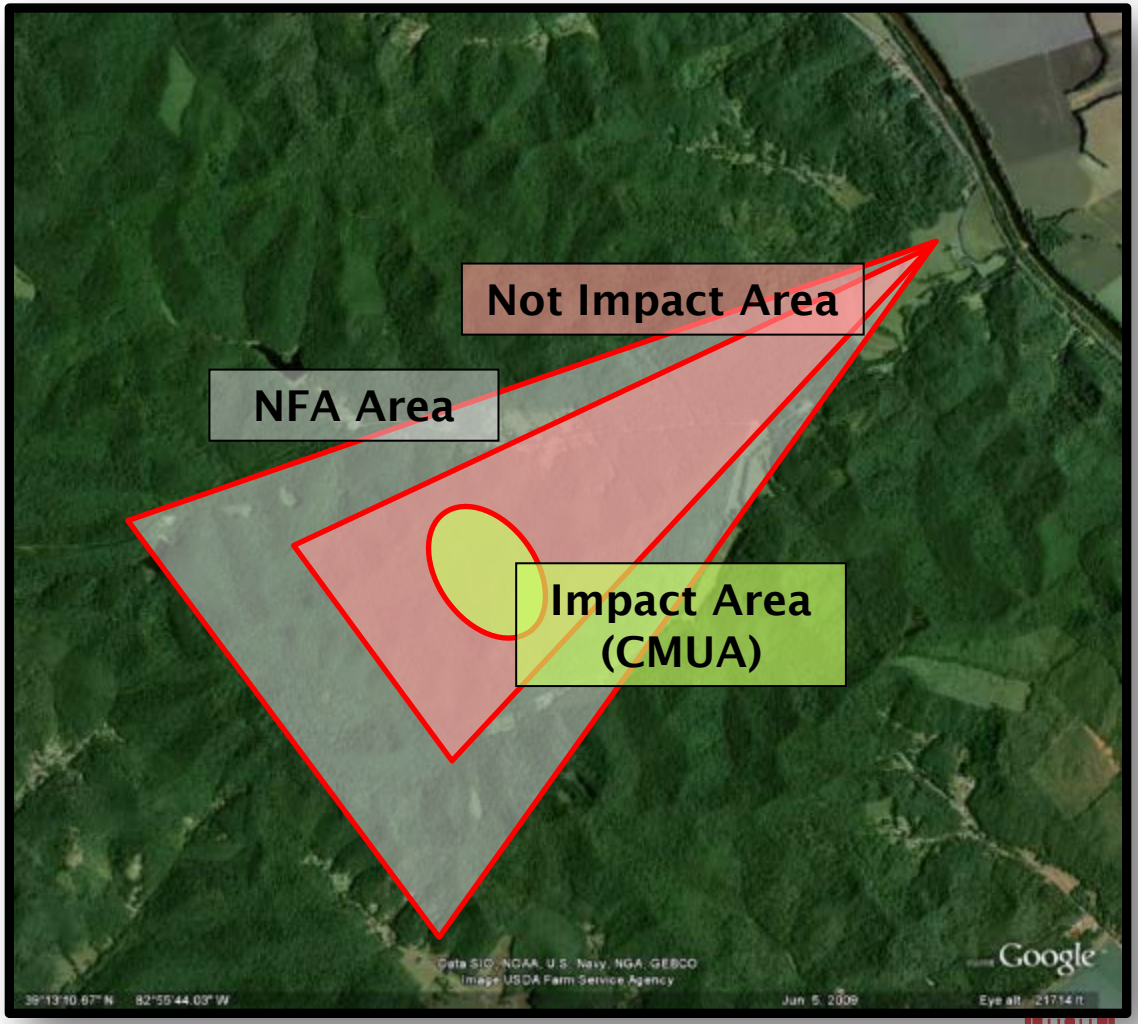
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MMRP & HTRW DIFFERENCE IN CSM CONCEPTS

HTRW: source → receptor

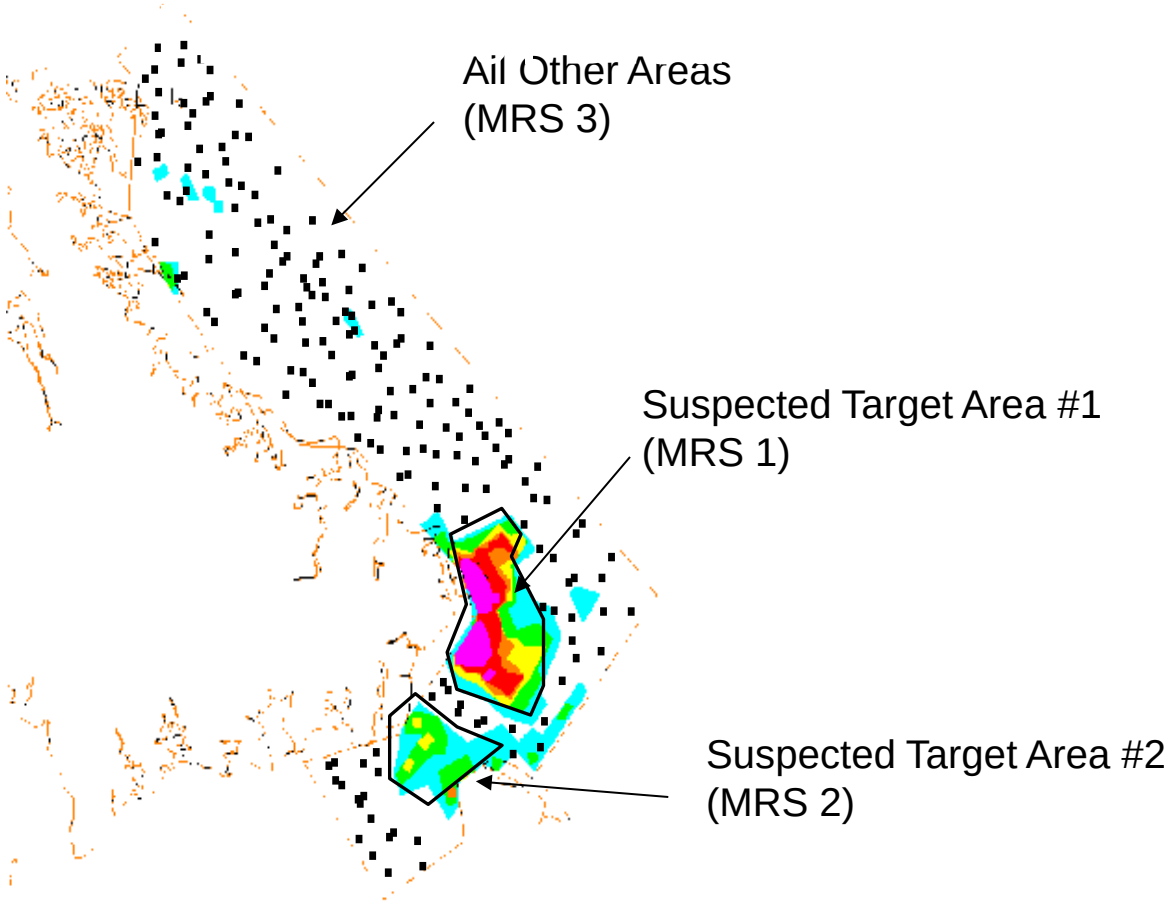
MMRP: source ← receptor

POTENTIAL RI RESULTS



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This example shows 209 grids (50’ x 50’) in MRS 3.

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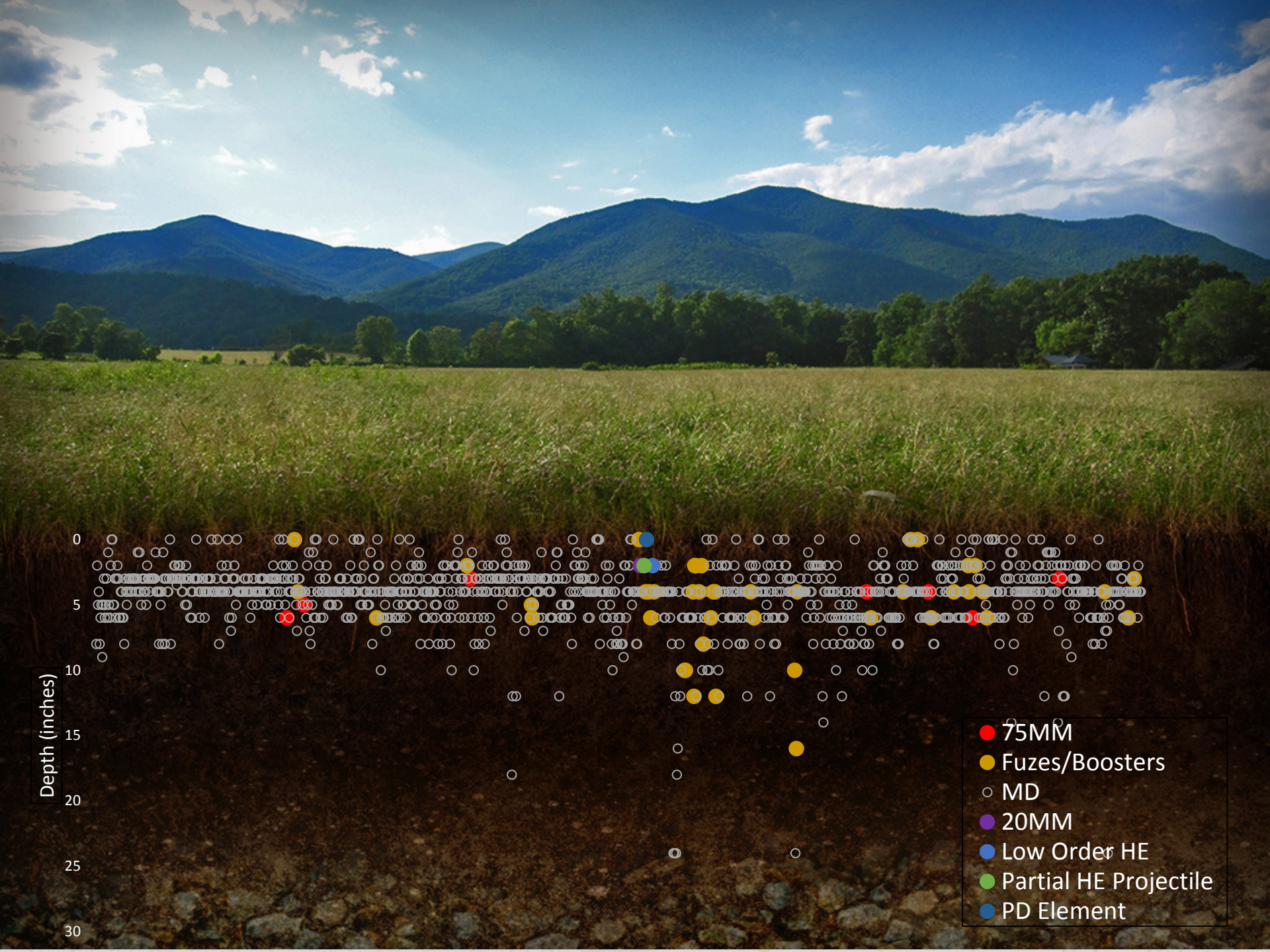
VERTICAL CSM

Critical for planning the remedial action.

- What's out there?
- How deep is it?
- Can we reliably detect it, and with what degree of certainty?

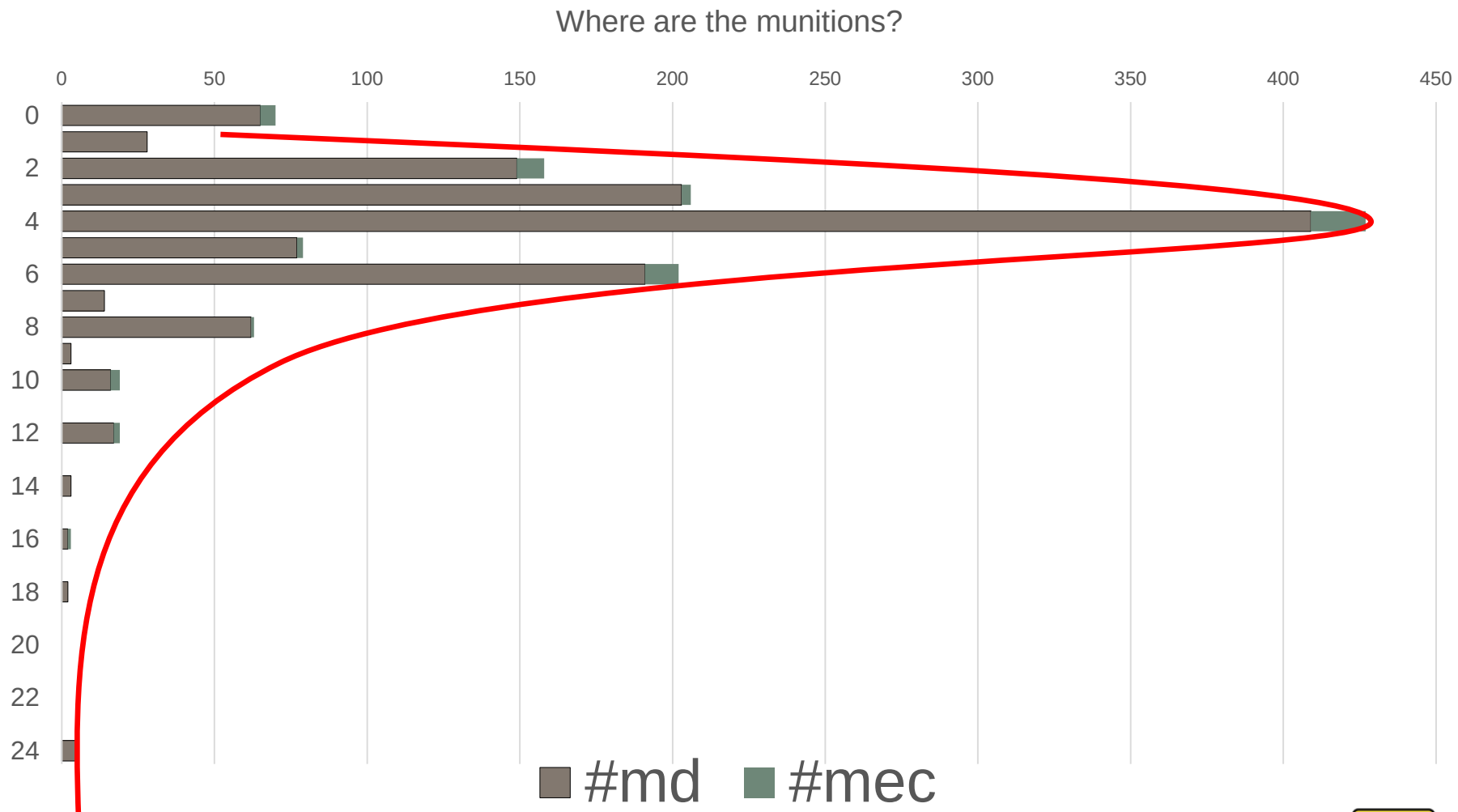
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0
5
10
15
20
25
30
Depth (inches)
75MM
Fuzes/Boosters
MD
20MM
Low Order HE
Partial HE Projectile
PD Element


0
5
10
15
20
25
30
Depth (inches)
75MM
Fuzes/Boosters
MD
20MM
Low Order HE
Partial HE Projectile
PD Element

FIRST CUTS AT [X] VS. DEPTH



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CHARACTERIZATION: VERTICAL DISTRIBUTION?



Surface

← Detection Limit (DL)

Land Use-Depth = Action Limit (AL)

Confidence →

← DL

Confidence →

←DL

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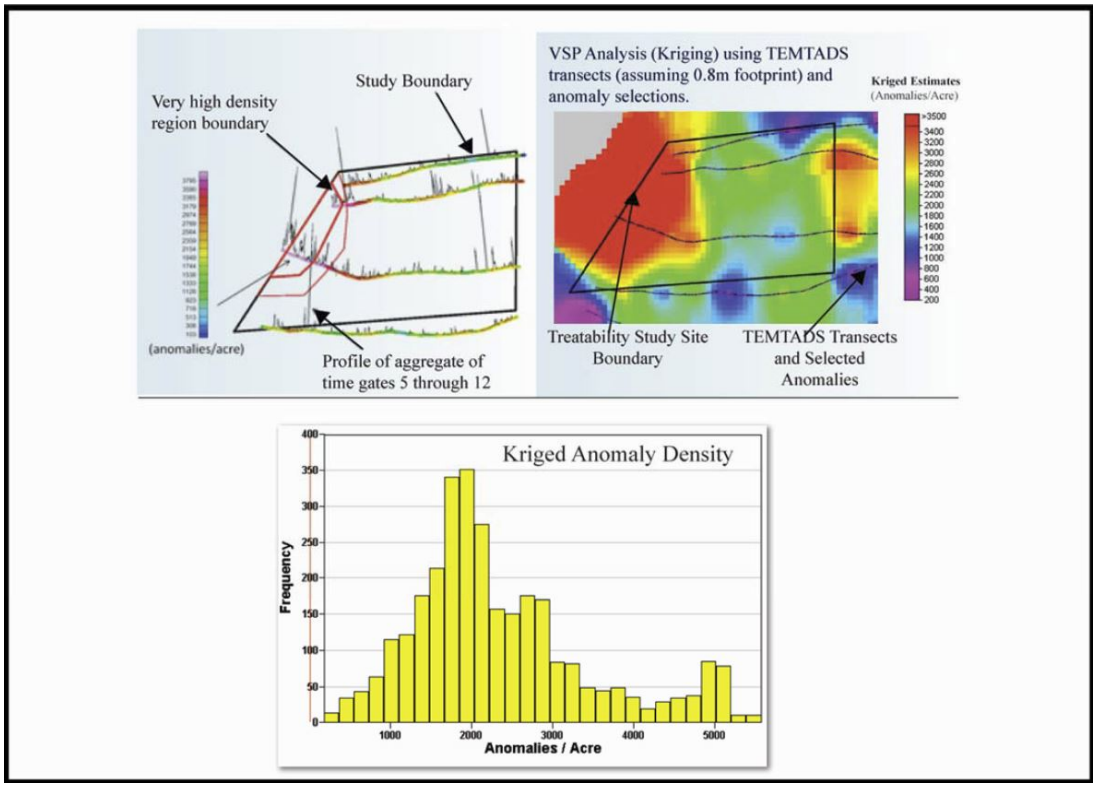
HOW DOES ALL THIS TIE-IN TO AGC?

AGC & Visual Sample Plan in the Remedial Investigation

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THE FUNDAMENTALS DO NOT CHANGE



Visual Sample Plan

- Find Target Areas (areas of Concentrated Munitions Use)
- Estimate upper bound of potentially remaining UXO (buffer areas or unused lands)
- Estimate numbers of anomalies

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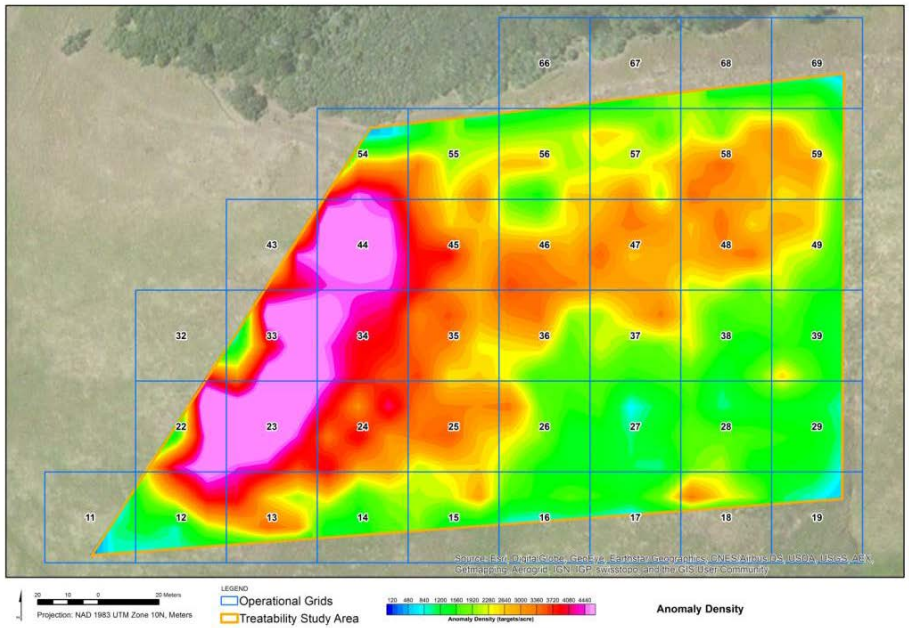
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EXAMPLES OF CMUA AND ANOMALY ANALYSES

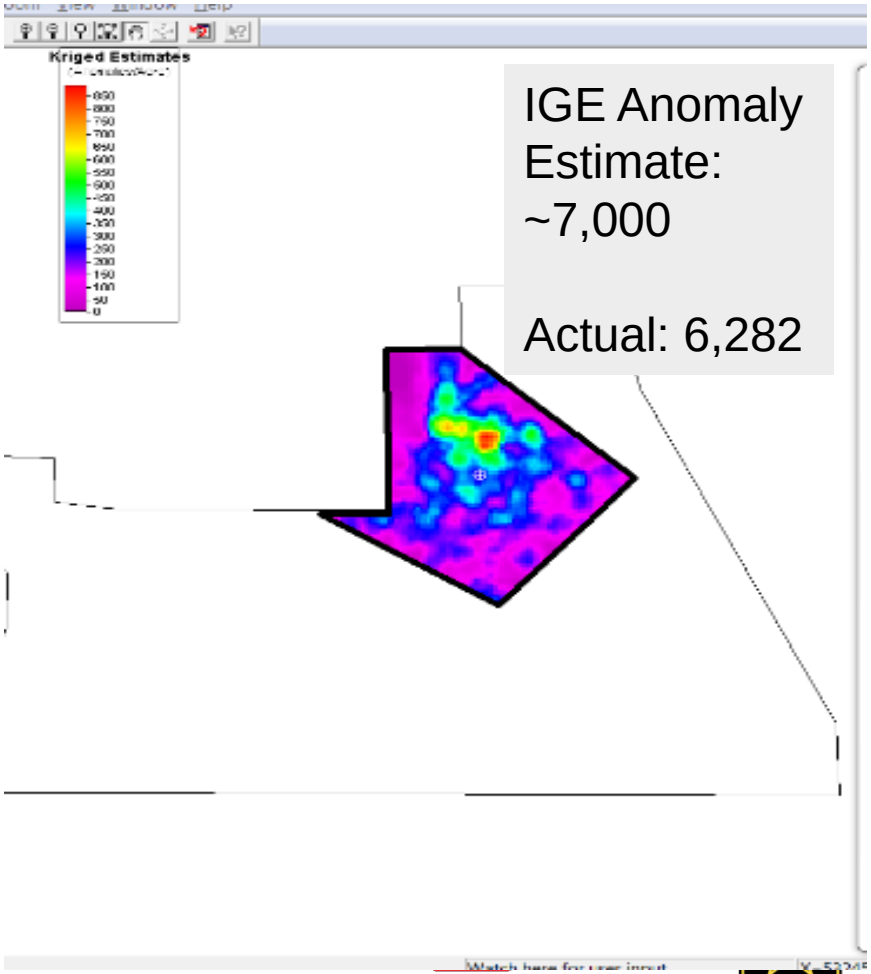
CSLO

IGE Anomaly Estimate:
15,000

Actual: 19,000



FLBGR



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AGC BENEFITS IN THE RI

Conventional Approach	AGC
Transects: $200K	Transects: $200K
Grids: $200K	Grids: $200K
Cueing: $0	Cueing: $300K
Digging: $400K	Digging: $100K
Project Total: $1M	Project Total: $1M
Total # Anomalies with answers: 2,000 to 3,000	Total # Anomalies with answers: **~8,500!**

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Uniform Federal Policy
for Quality Assurance Project Plans (UFP-QAPP)

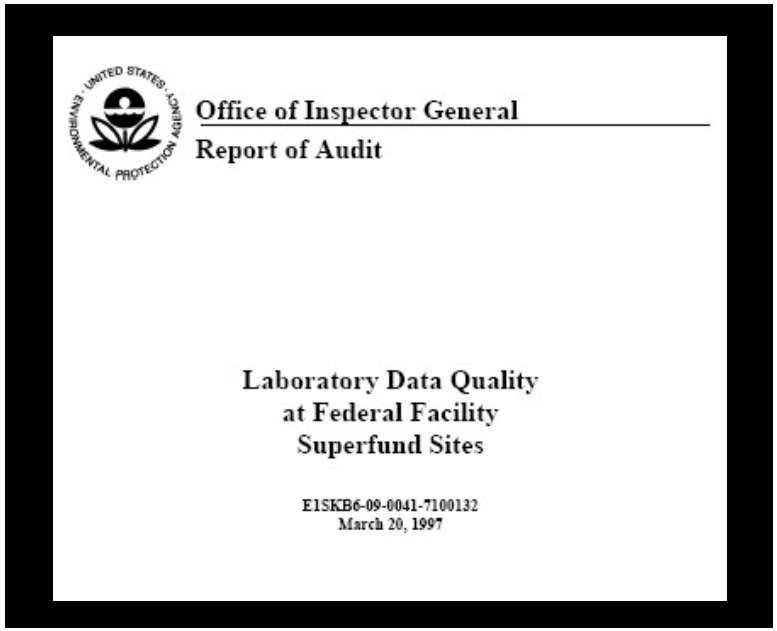
AGC Training QAPP Introduction

Movie: *Manager's Role in Assuring Data Quality: Overview of the Uniform Federal Policy for Quality Assurance Project Plans*

View/download:

https://www.epa.gov/sites/production/files/fedfac/manager_role_quality_data.mpg

Historical Overview



- Inspectors General
- Cited data quality issues
- Task force formed



Uniform Federal Policy

- Intergovernmental Data Quality Task Force (IDQTF)
  - Consensus workgroup
  - Representatives from EPA Headquarters and Regions, DoD services, and DOE
    - Navy chair DoD Environmental Data Quality Workgroup
      - NAVSEA Laboratory Quality and Accreditation Office

Information Quality Guidelines

- Required by the Data Quality Act- PL106-554 (2001)
- ...for Ensuring and Maximizing the Quality, Objectivity, Utility and Integrity of Information...
- In essence, requires that data have a pedigree that permits users and potential users to assess usability of data for specific purposes
- A good, implemented QAPP is the foundation of data pedigree

UFP for Implementing Quality Systems

- First Product of IDQTF
  - Signed by EPA and DOE (2002)
  - Signed by DoD (2003)

- Based on *Quality Systems for Environmental Data Collection and Environmental Technology Programs,* ANSI/ASQ E4 Section 5 (Part A)
  - Section 5, Management Elements of a Quality System

UFP for Quality Assurance Project Plans (UFP QAPP)

- Based on ANSI/ASQ E4 Section 6 (Part B)
  - Project-Specific
- Consistent with EPA QA/R-5 and QA/G-5
- Organized around four major QAPP elements
  - Project Management and Objectives
  - Measurements and Data Acquisition
  - Assessment and Oversight
  - Data Review

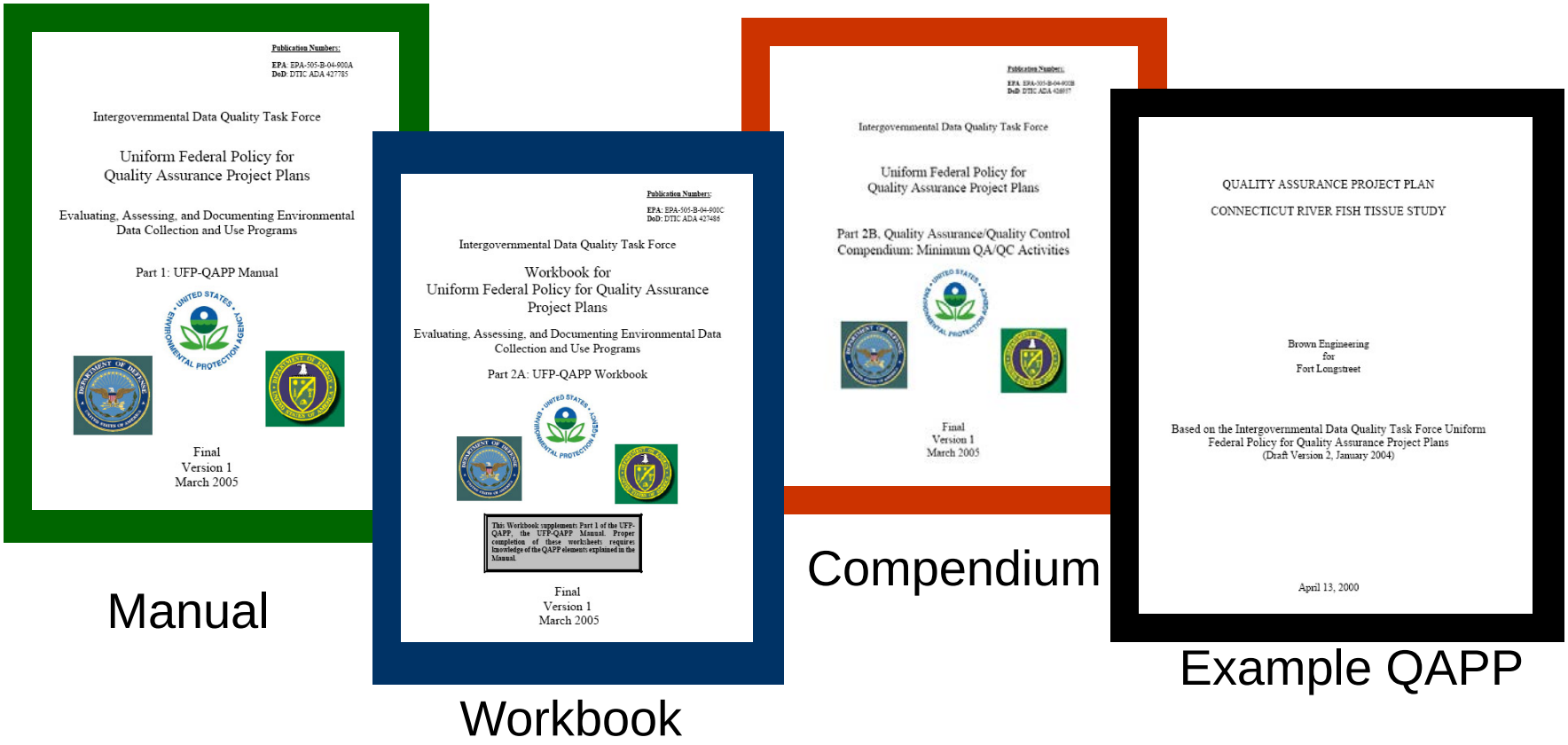
UFP-QAPP Implementation

- UFP-QAPP is voluntary consensus policy
  - Once adopted by Federal department, agency, or program, use is mandatory within that organization
- UFP-QAPP Manual signed by EPA (2004), DoD (2005)
- OSWER Directive 9272.0-17. June 7, 2005
- OSWER Guidance 9272.0-20. Dec 21, 2005
- Office of the Under Secretary of Defense Memorandum of April 11,2006
- DoD Instruction 4715.15 Dec 11, 2006

UFP-QAPP Documents

To download documents:

https://www.epa.gov/fedfac/assuring-quality-federal-cleanups



UFP QAPP

- PART 1 is the UFP work book manual
  - Provide instructions and guidance on QAPP preparation
- PART 2A is the blank forms
  - The forms are not mandatory, but facilitate ease of use
- PART 2B is the Compendium
  - Lists required QC activities for the CERCLA process A minimum set of requirements
  - Other Programs (e.g. RCRA) can use the Compendium if agreed by all parties

Overview of UFP-QAPP Manual

- Principles
  - Applicable to ***any*** environmental program
  - Minimum QA/QC activities - QA/QC Compendium
  - Documentation, detail and effort varies by project
  - Recommends use of worksheets
  - Cross referencing to other documents
  - Does not require rewrite of any current QAPP
- Applicable to:
  - Investigation
  - Remediation activities or remedy solutions
  - Final Clean-up and long term monitoring/stewardship activities

Format

- Follows ***Systematic Planning Process (SPP)***
  - Formal DQO Process (EPA QA/G-4) or other
- Fill-in-the-blank worksheets for each QAPP element from project team ***decisions***
- Allows for ***graded approach***
  - Amount of documentation and detail will depend on complexity and scope of project

Quality Assurance Project Plan (QAPP)

- Integrates technical and quality control aspects of a project including ...
  - planning, implementation, assessment, and corrective actions
- Documents steps taken to ensure environmental data are ...
  - of the correct type and quality required for a specific decision or use

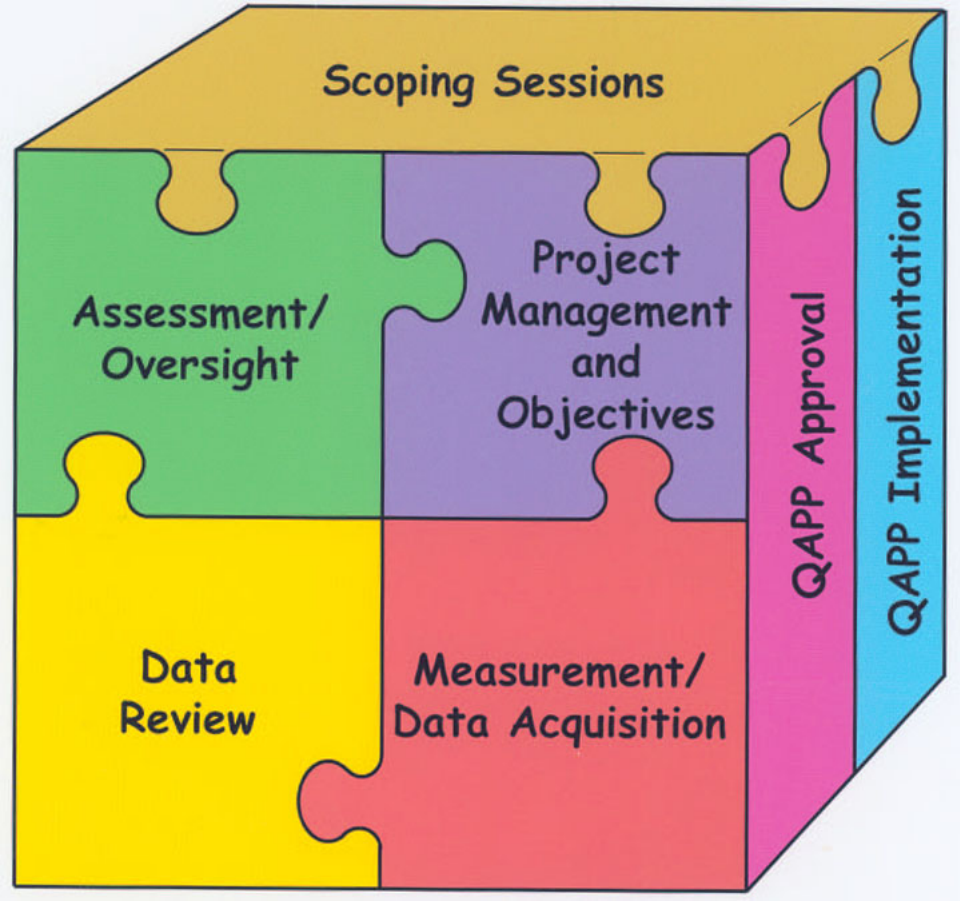
QAPP (Continued)

- Organized and systematic description of ...
  - quality assurance (QA)
  - quality control (QC)
  - application to the collection and use of environmental data

Other Documents

- Work Plans, Health & Safety, Sampling and Analysis Plans
  - Can be ‘stand–alone’ documents or incorporated into the UFP-QAPP using the graded approach
  - NAVFAC Sampling and Analysis Plan is the UFP QAPP
    - Work Plan refers to QAPP
    - Munitions and Chemical Templates available
- At a minimum, other documents must be REFERENCED in the UFP-QAPP

UFP-QAPP Process Elements



IDQTF Current Activities

- Worksheet streamlining
- MMRP implementation
  - Advanced Geophysical Classification (AGC) Template finalized
  - MMRP UFP QAPP Template under development to combine/standardize USACE/NAVFAC templates
- Looking into UFP QAPP templates for emerging contaminants

Review

- What is Systematic Planning?
  - Group effort to balance cost vs. amount of data needed to make decision
  - Understand how the data will be used
  - Ensure you get what you pay for by defining project needs in detail
  - Knowing what was & was not delivered and why

Better planning may add cost at the beginning of my project

Questions ??

Doug Maddox
USEPA Federal Facilities Restoration and Reuse Office
maddox.doug@epa.gov
202-564-0553

Navy Training: UFP-QAPP

John M. Jackson

Geophysicist

USACE- SPK/EMCX



US Army Corps of Engineers

BUILDING STRONG®

Uniform Federal Policy Quality Assurance Project Plan (UFP QAPP)

- UFP-QAPP is mandatory for all DERP (MMRP and IRP) funded environmental projects
- Requires:
  - The Right Technical Team
  - Systematic Planning
  - Development of Clear Data Quality Objectives
  - Defines Quality Checks before we start Field Work

UFP QAPP

is a:

SAMPLING & ANALYSIS PLAN (SAP)

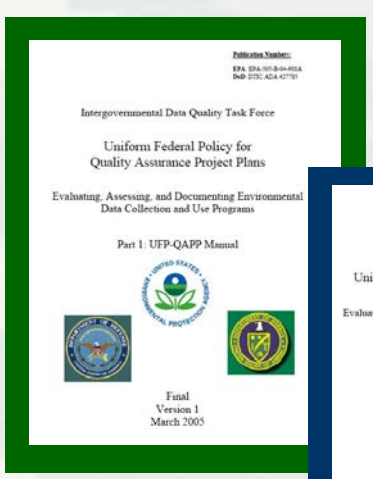
SAP = FSP + QAPP

→ **IT'S A WORK PLAN!!**

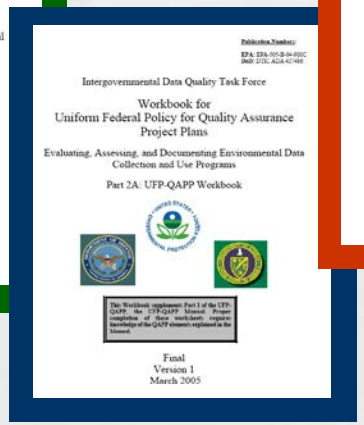
UFP-QAPP Documents

To download documents:

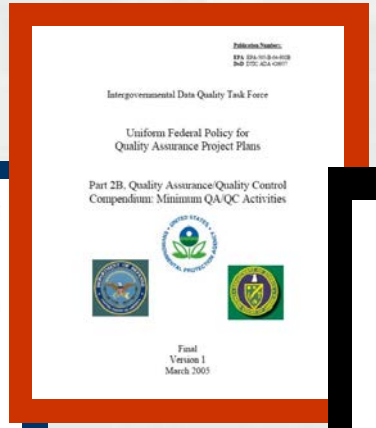
http://www.denix.osd.mil/edqw/Documents.cfm



Manual



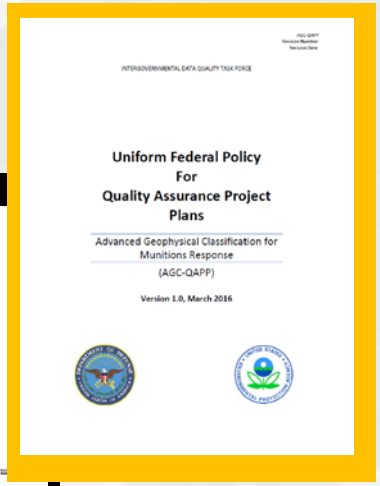
Workbook



Compendium



Example QAPP



AGCMR QAPP Template

Worksheet Templates

- Prompt Planning Process
- Organized by Process Elements
  - WS's 1-8: Management Background, PDT Lead Agency, Training Requirements, Proof of Review, and Approval Pages
  - WS 9: Documents ALL Project Meetings and Agreements
  - WS's 10-16: Project Objectives CSM & DQO Development, and Performance Objectives.
  - WS's 17-30: Design and Data Collection, and Quality Control Requirements
  - WS's 31-33: Assessment and Oversight
  - WS 34-37: Data Review

Before You SPP (whole team)

- Take to First Scoping Meeting:
  - Management and Organization Worksheets
    - ▷ Worksheets 1- 8
  - Planning Worksheets
    - ▷ 10: CSM
    - ▷ 11: Data Quality Objectives
    - ▷ 12: Measurement Performance Criteria
    - ▷ 13: Secondary Data; Use and Limitations
    - ▷ 15: Project Action Limits: Usually a Chemistry Parameter.
      - ○ For MMRP -- *Land Use Depth.*
    - ▷ 17: Study Design and Rational
    - ▷ 22: QC, Equipment Testing, Inspection
    - ▷ 14 & 16: Tasks and Schedule
  - *Document Agreements / Discussions in Worksheet 9!*

Organization Structure: Safety

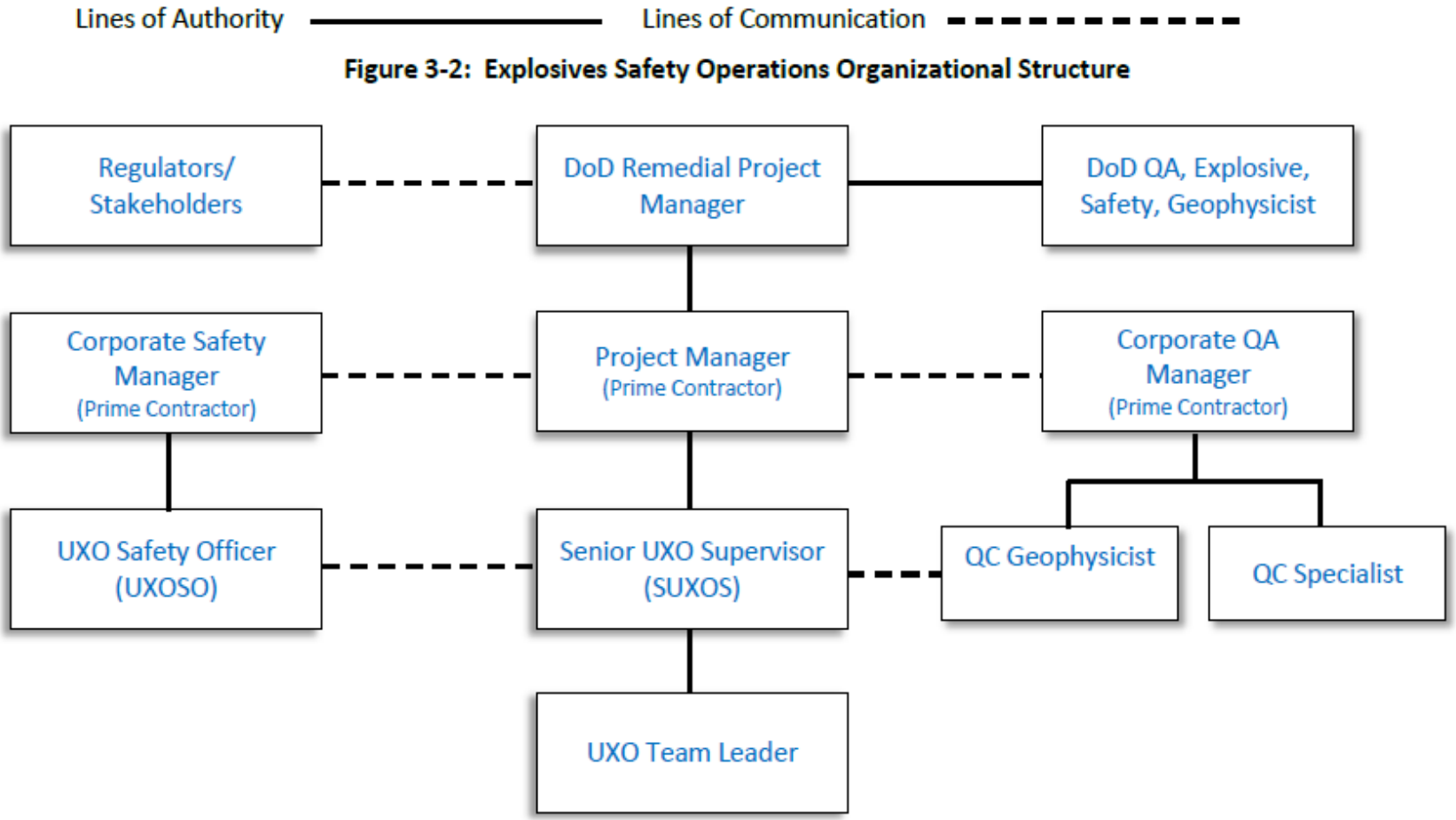


Figure 3-2: Explosives Safety Operations Organizational Structure

Organization Structure: Geophysics

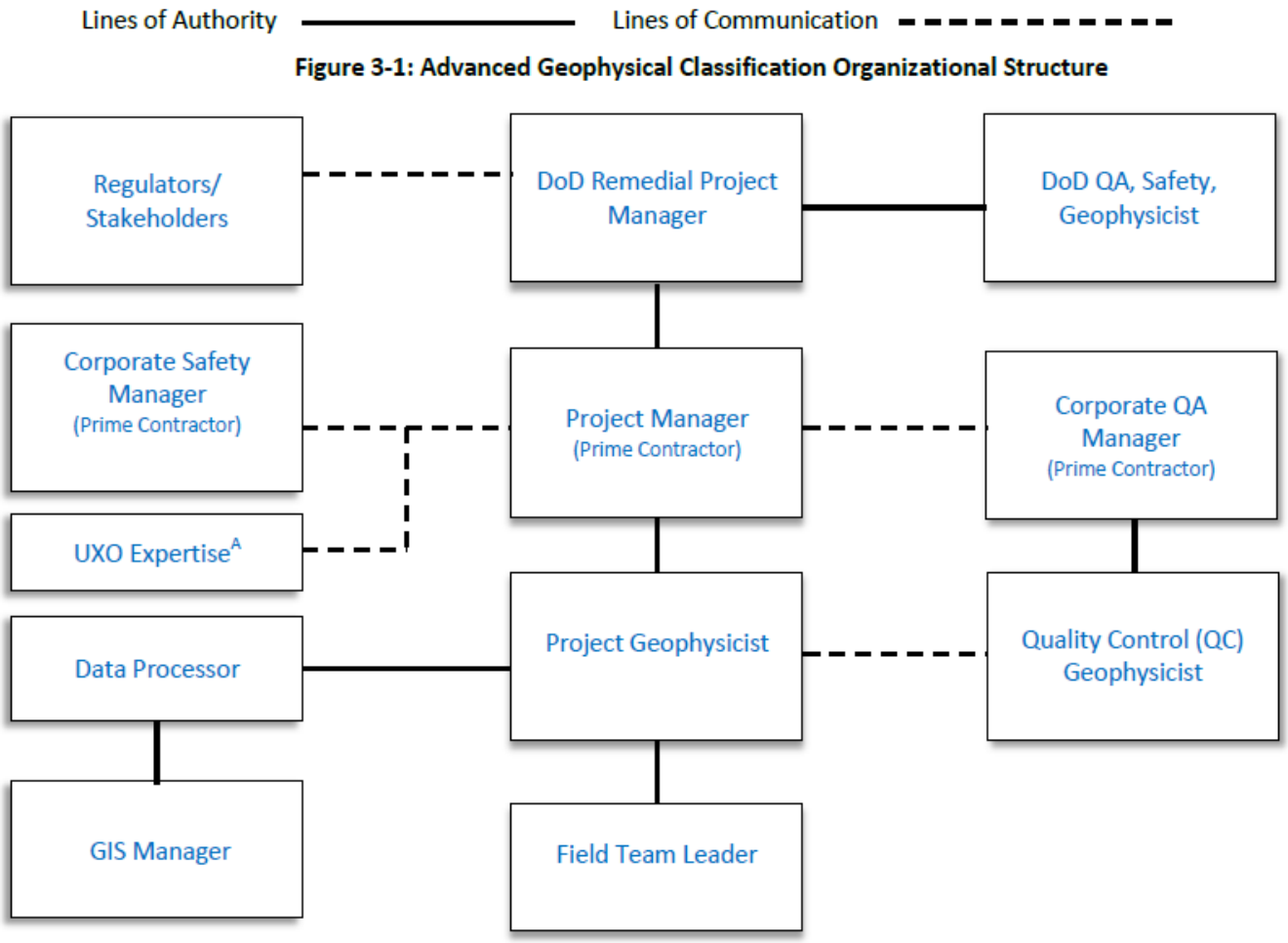


Figure 3-1: Advanced Geophysical Classification Organizational Structure

[A] UXO expertise is required to make sure the TOI, which can range from intact munitions to sub-components or fragments with residual explosive and/or chemical constituents, are defined.

Worksheets 1-8: Lessons Learned

- Section 1.3.5 of the UFP QAPP Manual,

  "…all lead organization's project personnel are to be listed and roles must be assigned and sign off on those rolls…"

- Section 2.3.1, "key personnel includes those working for the lead organization"
- Section 2.4.1 supports inclusion of the lead agency personnel, including data review personnel.

  - DoD (not contractor) is the lead.
  - Include QA technical team members, specifically the geophysicist, chemist, and OESS in org structure.
  - Include Contractor field team leads and QC, not just Contractor PM, Geophysicist and OESS, unless they are the field team leads.

Worksheet #6- Communication Pathways

Communication Driver	Initiator (name, title/role, and contact info)	Recipient (name, title/role, and contact info)	Procedure (timing, priority, documentation)
Regulatory agency interface	Name, DoD RPM Phone/email	Name, Organization Phone/email	USACE PM provide weekly project update memorandum to Regulator via email
Stop work due to safety issues	Name, Contractor SUXOS Phone/email	Name, Contractor PM Phone/email	As soon as possible following discovery, SUXOS informs Contractor PM by phone of critical safety issues and generates follow-up Stop Work Memorandum
Minor QAPP changes during project execution			
Major QAPP changes during project execution	Name, Contractor PM Phone/email	Name, USACE PM Phone/email	Within 24 hours, Contractor PM submits field change request form to USACE PM for approval. Following approval, USACE PM informs regulator via email.
Mobilization and surface clearance activities are complete	Name, Contractor SUXOS Phone/email	Name, USACE QA & Safety Phone/email	Upon completion of surface clearance activities, the SUXOS informs the USACE QA & Safety via Surface Clearance Memorandum
Field progress reports	Name, Contractor PM Phone/email	Name, USACE PM Phone/email	At end of each day of field work, Contractor PM provides daily QC reports to USACE PM via email

Communication, Communication Communication!!!

WS 10: Conceptual Site Model (CSM):

(UFP-QAPP Manual Section 2.5.2)
(EPA 2106-G-05 Section 2.2.5)

- Narrative history supported by
  - ►Figures / Graphic Model
  - ►Tables
- Updated as new data are collected.
- Multiple sites, unique problems, →separate CSM for each
- ***Data gaps and uncertainties in the CSM clearly identified.***

- Background – description, history, including key physical aspects (e.g., site geology, hydrology, topography, climate);
- Sources – Range type, known or suspected munitions (MEC/MC);
- Release Mechanism - including fate and transport considerations;
- Land use & Receptors / Pathways - potential for exposure;
- Model - nature and extent (Consider Air-to-ground, vs artillery fan, vs multi- use ranges, etc.)

[1] Guidance on Systematic Planning Using the Data Quality Objectives Process, U.S. EPA, EPA QA/G-4, February 2006.
[2] Technical Project Planning Process, U.S. Army Corps of Engineers, EM 200-1-2, August 1998

How to Use WS # 10?

- Identify Data Gaps
  - NOTE: data gap does not = data need
- Present What We Know
  - Known or Suspected Munitions (Specifically)
  - Confirmed as Practice? Training? Live?
- Define What We Need to Know
  - Can we define an unacceptable risk?
  - What other data will we need to make these decisions?

WS # 10: CSM
Narrative Supported by Graphic Model

- Background Information,
  - i.e. Site History
- Define the MRS
  - Acreage & Map
- Primary Release Mechanisms for MEC/MC
  - Ground to ground
  - Air to ground
  - Burial…etc.
- Findings from Previous Studies
- Fate & Transport

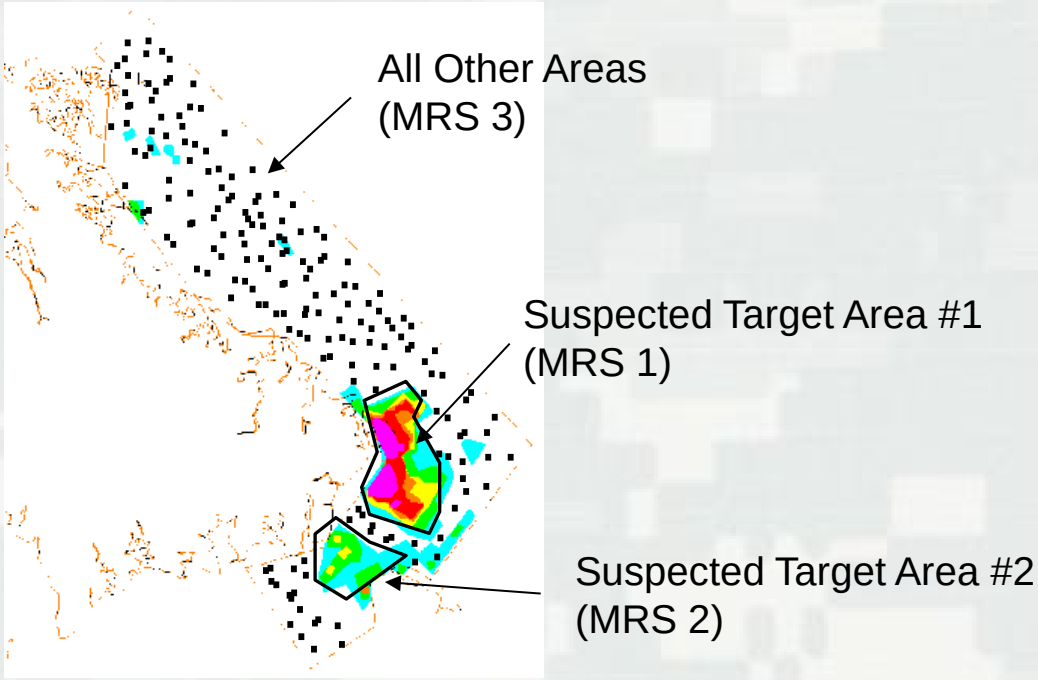
- Sources of Known or Suspected MEC/MC
  - Types of Known/Suspected MEC/MC
  - Anomaly Distribution
    - Are there Concentrated Munitions Use Areas (CMUAs)?
    - Can we define Depth of Distribution?

Worksheet # 10 Cont'd

- Key physical aspects
  - Geology - background?
  - Topography / Terrain
  - Vegetation
  - Runoff/Groundwater
- Land use considerations
  - Accessibility
  - Ownerships/ ROEs, Parcel Map
  - Potential receptors and exposure pathways
    - Man hours
    - Depth of use, specific site activities and users
  - Surrounding Use
  - Existing Deed Restrictions or Controls

GOOD

Traditional Report on Characterization: Horizontal Distribution



This example shows 209 grids (50’ x 50’) in MRS 3.


0
5
10
15
20
25
30
Depth (inches)
75MM
Fuzes/Boosters
MD
20MM
Low Order HE
Partial HE Projectile
PD Element

Worksheet # 9 Project Scoping Session Participants & *Agreements*

Project Name: Projected Date(s) of Sampling: Project Manager:		Site Name: Site Location:			
Date of Session: Scoping Session Purpose:					
Name	Title	Affiliation	Phone	E-mail Address	Project Role

Document, Document, Document !!

So the PDT Agrees to the CSM

- Document Decisions in Worksheet #9

So Now Let's DQO!!!

Systematic Planning: Developing DQOs

- Uses what we know about the Site
  - Develop Plan for Additional Data Needs
- What kind of data do we need?
  - During Characterization?
  - During Remedial Action?

Understanding DQOs

- Who will use the data?
- What will the data be used for?
- Phase of Data Acquisition?
  - ▶ Remedial Investigation?
    - Characterization
  - ▶ Remedial Action?
    - Support Confidence & Achievement of RAO

SO, We Have the CSM

Worksheet 10: CSM

- Develop the Story
- Lead into the Problem
- Supports Need for Further Remedial Response

Worksheet 11: DQOs

- Step 1: Problem Statement
- Step 2: Goals of the Study
- Step 3: Information Inputs
- Step 4: Boundaries
- Step 5: Analytic Approach
- Step 6: Performance Objectives
- Step 7: Detailed Plan to Obtain Data

How to Use WS #11?

- 7 Step DQO Process
  - ►Template Prompts each of 7 steps.

- First, see the template.

WS # 11 DQOs: Steps 1-4

(UFP-QAPP Manual Section 2.6.1)
(EPA 2106-G-05 Section 2.2.6)

Document project quality objectives (PQOs) or data quality objectives (DQOs) using a systematic planning process (SPP)

EPA's 7 Step DQOs:

1. **State the Problem**. - consistent with the CSM (data gaps).

2. **Identify the Goals of the Study**. specific study questions with alternative outcomes.

(Explain goals in terms of how the data will be used to choose among the stated outcomes.)

3. **Identify Information Inputs.**
a. Specify the types of data required to fill data gaps.
b. Explain in specific terms how all data will be used.

4. **Define the Boundaries of the Study.**
a. Specify the target population and characteristics of interest, define spatial /temporal limits and the scale of inference (i.e., which populations will be represented by which data.)

[1] Guidance on Systematic Planning Using the Data Quality Objectives Process, U.S. EPA, EPA QA/G-4, February 2006.
[2] Technical Project Planning Process, U.S. Army Corps of Engineers, EM 200-1-2, August 1998

DQOs Step 1: The Problem

End of the RI:

- Extent
- Nature
- Unacceptable risk?

During Feasibility Study:

- Develop the RAO
- Assess Paths to RC

End of the RA:

- Verify CSM assumptions
- Confidence in Remedial Action
- Support Achievement of RAO

Difference in Planning for RI & RAs

Remedial Investigation

- Determine Extent
  - Vertical & Horizontal
- Land Use
  - Accessibility
  - Site Activities
- Munitions
  - Sensitivity
  - Severity
- Determine Risk
  - Acceptable vs Unacceptable

Remedial Action

- Remediate!!
  - Meet the RAO
- Confirm CSM

The UFP QAPP Template for AGC: Remedial Investigation vs. Remedial Action

RI Template



RA Template

AGC-QAPP
Revision Number:
Revision Date:

INTERGOVERNMENTAL DATA QUALITY TASK FORCE

Uniform Federal Policy
For
Quality Assurance Project Plans

Advanced Geophysical Classification for Munitions Response

(AGC-QAPP)

Version 1.0, March 2016

AGCMR QAPP Template

So We Have an Unacceptable Risk



And We Have the
Decision Document



DQO Steps 1 & 2:
Remedial Action

- Support Achievement of RAO
- Support Confidence in Remedial Action
  - Depth of Detection/Retrieved vs Land Use Depth
  - Verify Horizontal and Vertical Distribution
- Achieve an Acceptable End State
  - Determine if remedy (UU/UE or other) can be supported (MQO/DQOs met and CSM confirmed)
  - Determine if additional response required (CSM or DQOs were not achieved; maybe ESD?)

From The AGCMR QAPP

Step 1: State the Problem. Define the problem that necessitates the study. Examine budget and schedule issues.

Site-specific problem statement: (Example) Previous investigations (list) have indicated that MEC in the form of DMM and UXO including (x, y, and z) are present at site _____, resulting from its use between (years) _____and_____ as a (describe the type of facility and its uses). As shown in the CSM these materials present an unacceptable risk from explosive hazards to (describe current receptors and potential future receptors based on anticipated land use.)

Advanced geophysical classification uses advanced sensors and geophysical classifiers to estimate physical properties of the item (e.g., depth, size, aspect ratio, wall thickness, symmetry) and determine whether the item is a TOI (i.e., highly likely to be MEC) or non-TOI (i.e., highly unlikely to be MEC). Using this information in a structured decision-making process, project teams will be able to make informed decisions about whether an item should be excavated or can be left in place.

Worksheet 11: Step 2, Goals of the Study

Step 2: Identify the goals of the data collection. State how data will be used in meeting objectives and solving the problem. Identify study questions, including RA objectives. Define alternative outcomes.

Identify the principal study question: (Example) Based on current and anticipated future land use scenarios, which detected buried metal objects must be removed, and which ones may be left it place?

Identify alternative outcomes: (Example) To classify an object as a TOI and remove it, or to classify it as non-TOI and leave it in place.

State how the data will be used in solving the problem: (Example) Advanced geophysical classification will be used to 1) detect anomalies resulting from DMM, UXO, and other metallic debris and 2) classify anomalies so that informed decisions can be made as to whether the anomaly results from a TOI that should be removed, or a non-TOI that may be left in place. Geophysical data collected using advanced EMI sensors in a dynamic mode will be used to initially detect and document the locations of subsurface anomalies. Geophysical data collected using advanced EMI sensors in a cued (static) mode will then be used to classify each anomaly as follows: 1) TOI, i.e., highly likely to be DMM or UXO; 2) Non-TOI, i.e., highly unlikely to be DMM or UXO; or 3) Inconclusive. Detected items classified as "TOI" and "inconclusive" will be targeted for removal. Items classified as non-TOI will be left in place. The results of geophysical detection and classification and the subsequent intrusive investigation must meet established DQOs to allow the anticipated land reuse to take place after the removal of TOI.

DQOs Step 3: Information Inputs

- What type of data are needed?
  - Magnetometer, EMI, digital geophysical mapping
  - Detection capabilities meet land use depth??
- Data Gaps
  - True Vertical and Lateral Extent
  - Detection Depth Achieved
  - Background S/N ratio

Data Needs for the Remedial Action

- Boundaries (resulting from RI, Defined in DD)
- Remedial Action Objective
  - Contaminant & Media (from RI)
  - Depth, to Protect Specific Users (from RI)
  - The Objective
- Specific Type of Munitions
  - Size, ~Detection Limits
  - Sensitivities, Severities

DQOs Step 3: Information Inputs

- The AGC QAPP is comprehensive
  - Detection Components
  - Cueing Components
  - Intrusive Components

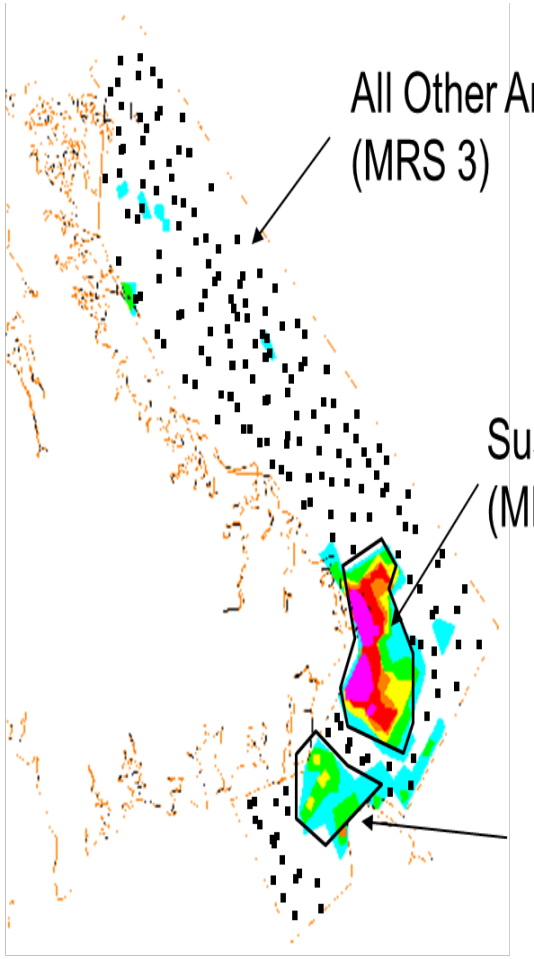
Step 3: Identify information inputs. Identify data and information needed to answer the study questions.

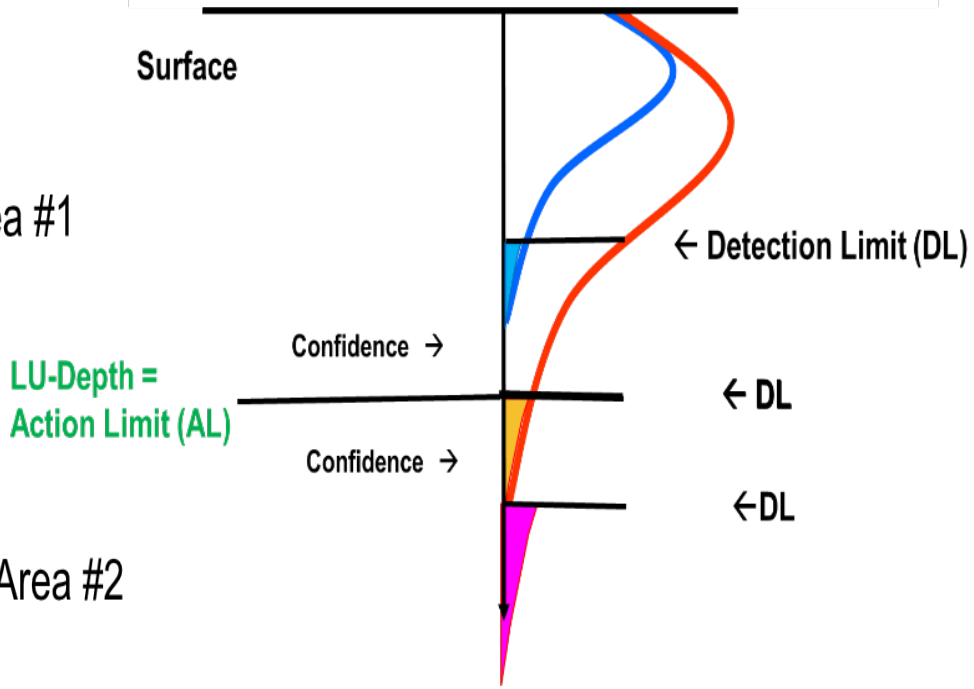
(Example)

- Up-to-date CSM summarizing site conditions based on previous studies (e.g., Preliminary Assessment (PA), Site Inspection (SI) and Remedial Investigation/Feasibility Study (RI/FS)). [See Worksheet #10]:
- Detection survey results, including:
  - Areas covered
  - System QC test results
  - Instrument Verification Strip (IVS) results
  - Surveyed validation seed and QC seed locations
  - Anomaly detections and responses
  - Data analysis results, including
    - Anomaly locations
    - Unique anomaly identification numbers
    - Z-component amplitude and dipole response for each anomaly
    - Detection survey data validation report
    - Detection survey data usability evaluation
    - Updated CSM
- Cued survey results, including:
  - System QC results
  - IVS results
  - Background data
  - Surveyed validation seed and QC seed locations and types
  - Unique anomaly identification numbers and locations
  - Site-specific munitions library
  - Definition of items representing unacceptable explosive hazard
  - Classification of anomalies with confidence metric
  - Cued survey data validation report
  - Cued survey data usability evaluation

Etc…

Worksheet #11: Step 4 - Boundaries





This example shows 209 grids (50' x 50') in MRS 3.

From The AGCMR QAPP

Step 4: Define the boundaries of the project. Specify the target population and characteristics of interest. Define spatial and temporal boundaries. [Discuss NAOC Comment 129]

Target population: (Example) The target population for this study includes the following MEC confirmed or suspected to exist in the study area:

Table 11-1: Target Population

Confirmed Munitions (including nomenclature, if known)	MEC Type (UXO, DMM, or both)	Munition Length	Observed Depth of Penetration (to center of mass)	Expected Detection Threshold
37mm (unknown mark/mod)	UXO			
75mm (unknown mark/mod)	UXO			
Suspected Munitions (including nomenclature, if known)	**MEC Type (UXO, DMM, or both)**			
60 mm mortar, M49A3	UXO			
155mm, M107	UXO			

Characteristics of interest: (Example) The characteristics of interest are those characteristics (e.g., size, symmetry, aspect ratio, object density, and wall thickness) that will allow classifiers to determine whether an anomaly is a TOI or non-TOI.

DQO Steps 1-4

Lots to Digest here…

…and not even finished with WS #11!

(We still have DQO steps 5-7…)



Data Quality Objectives: Steps 5-7

UFP QAPP Worksheet #11:
(UFP-QAPP Manual Section 2.6.1)
(EPA 2106-G-05 Section 2.2.6)

5 . Develop the Project Data Collection and Analysis Approach.

Define the parameter(s) of interest, and develop the logic or statistics for drawing conclusions from findings.

(What kind and how much data?)

For decision problems -"if---then" statements, or decision rules, to link potential results with outcomes.

6. Specify Performance/Acceptance Criteria.

Develop performance criteria (for new data being collected) or acceptance criteria (for existing data being considered for use).

Focus on WS # 12 & 22

7. Develop Detailed Plan for Obtaining Data

WS #11 overview of sampling design
WS #17 -design details.
WS #19, 20, 24-28, and 30 – analysis design requirements.

[1] Guidance on Systematic Planning Using the Data Quality Objectives Process, U.S. EPA, EPA QA/G-4, February 2006.
[2] Technical Project Planning Process, U.S. Army Corps of Engineers, EM 200-1-2, August 1998

From The AGC QAPP

Cued Phase

Parameters of interest: (Example) Spatial extent of detected anomaly, cued measurement SNR, inversion fit coherence, and inversion outputs of β1, β 2, β3, x, y, and z.

Type of inference: (Example) If any of the following three criteria are met, the anomaly will be selected as a TOI: 1) the polarizability matches (within specifications established on Worksheet #22) that of an item in the project-specific TOI library, 2) estimates of the size, shape, symmetry, and wall thickness calculated from the polarizability, indicates the item is long, cylindrical, and thick-walled, or 3) there is a group (cluster) of x or more anomalies having similar polarizabilities that, after investigation, are discovered to be TOI. Anomalies with poor inversion fit coherence that, after considering all available information, cannot be ruled as non-TOI (i.e., the data are inconclusive) will be added to the TOI list.

Decision rules: (Examples)

- If all or a portion of the study area is determined to have an anomaly density too high for cued analysis, then an alternative approach will be developed (factors for evaluating anomaly density are discussed in Worksheet #17).
- If the object is classified as TOI (highly likely to be a munition), then the object will be excavated.
- If the object is classified as non-TOI (highly unlikely to be a munition), then the object will be left in place.
- If the object is classified as inconclusive, then the object will be excavated.

Data Quality Objectives: Steps 5-7

UFP QAPP Worksheet #11:
(UFP-QAPP Manual Section 2.6.1)
(EPA 2106-G-05 Section 2.2.6)

5 . Develop the Analytic Approach.
Define the parameter(s) of interest, and develop the logic or statistics for drawing conclusions from findings.

(What kind and how much data?)

For decision problems -"if---then" statements, or decision rules, to link potential results with outcomes.

6. Specify Performance/Acceptance Criteria.

Develop performance criteria (for new data being collected) or acceptance criteria (for existing data being considered for use).

Focus on WS # 12 & 22

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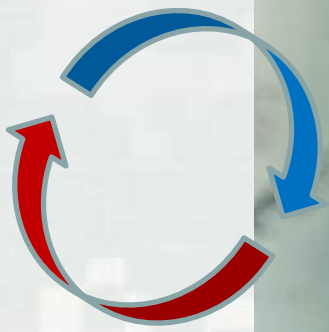
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[2] Technical Project Planning Process, U.S. Army Corps of Engineers, EM 200-1-2, August 1998

WS 11: Steps 6

Step 5: Develop Approach

- Advanced Classification
  - Discuss Applicability
  - Benefits
  - Limitations



Step 6: Measurement Performance Criteria



Worksheet #12

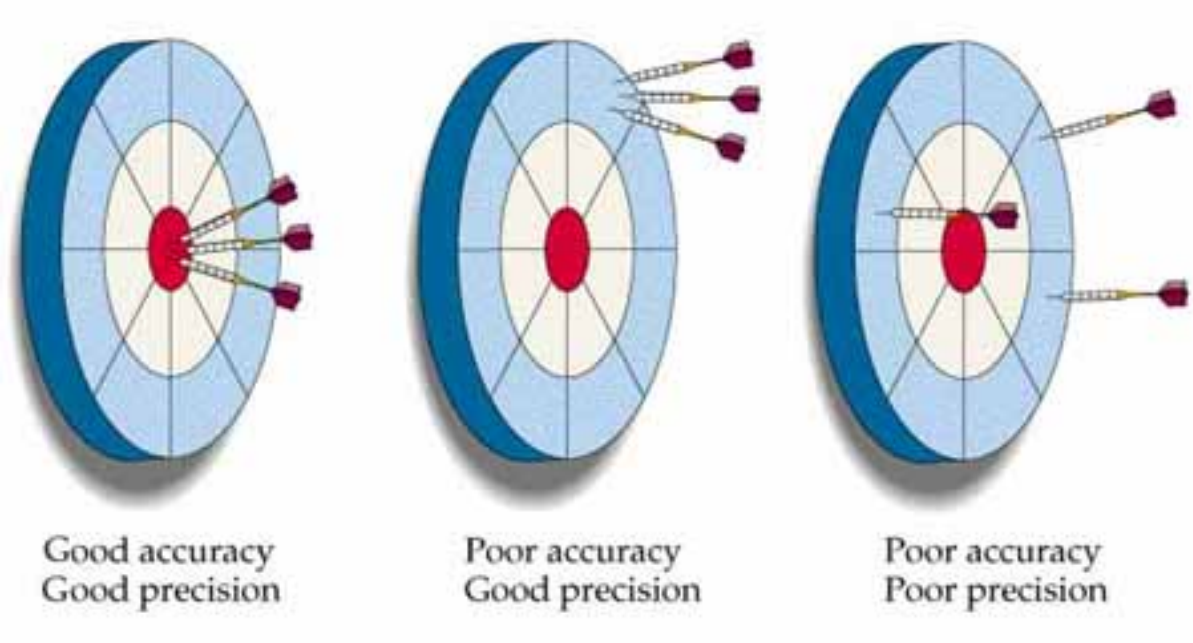
Measurement Performance Criteria

- Quantitative measurement of data quality.
- Tabulated for the following activities.
  - General measurement performance criteria
  - Geophysical Instrument functionality
  - Positioning instrument functionality
  - Data collection
  - Data processing
  - Auditing procedures
  - Other project requirements



Data Quality Indicators

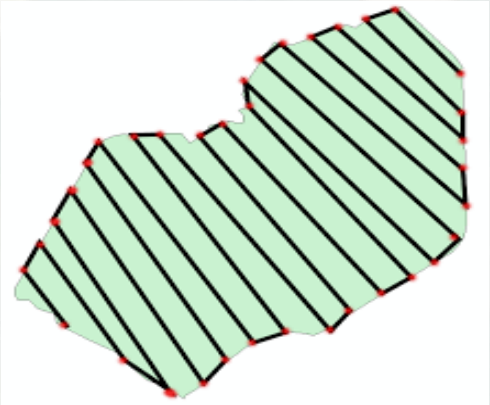
Data Quality Indicators



- Precision
- Accuracy
- Representativeness
- Completeness
- Comparability
- Sensitivity

Example, Develop Performance Criteria for Advanced Geophysical Classification

- DQI's addressed for each measurement phase/activity
- Three phases in AGC:
  - Detection (Dynamic) Survey
  - Classification (Cued) Survey
  - Intrusive Survey



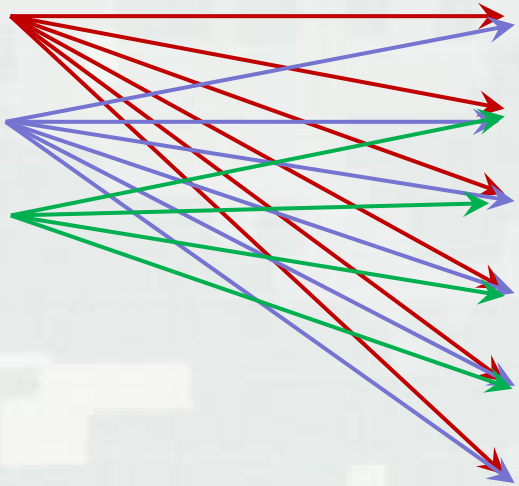




Phases for Advanced Geophysical Classification

3 Phases of AGC Data

a. Dynamic
b. Cued
c. Intrusive



DQI for each Phase

- Precision
- Accuracy
- Representativeness
- Completeness
- Comparability
- Sensitivity

Worksheet Development:



Dynamic Survey QC

- Performance Objectives:
  - verify geophysical sensor is operating properly, and
  - provide ongoing monitoring of the data quality.

- Two key elements:
  - **Instrument Verification Strip (IVS)**
  - **Production Area Blind Seeding**
    - **Contractor QC seeds and**
    - **Blind QA/validation seeds**

Step 6: Performance Criteria

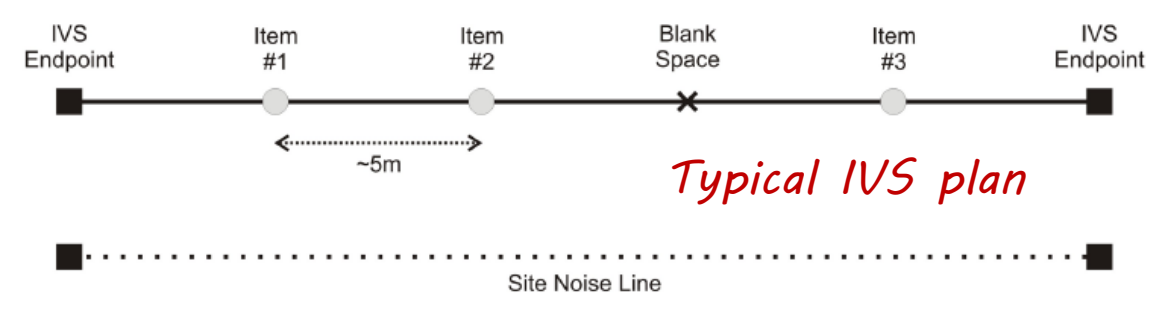
IVS

- Confirms that the geophysical detection system is operating properly
  - Usually single pass over an IVS line before start and after completion of production work each day.

QC & Validation Seeding

- Ongoing monitoring of the quality of data collection and analysis as it is performed
  - Expect 1-3 per day, one at limit of detection depth
- QC seed failure results in CA in the Field
- QA seed failure results in loss of confidence in data and the whole system

IVS Requirement



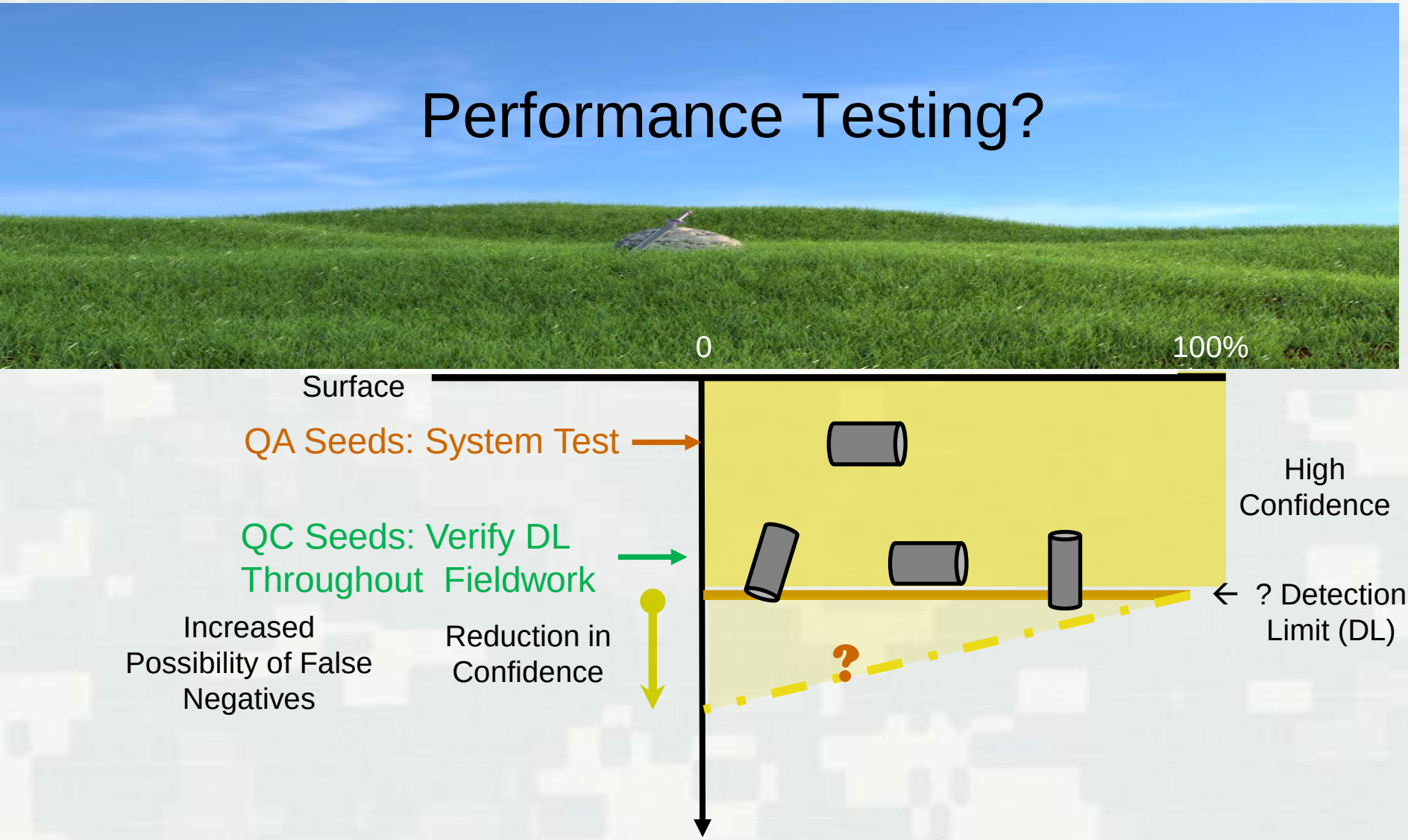
IVS

- Define Project's minimum frequency for IVS and necessary criteria to demonstrate instrument is fully functional.

Criteria

- Different for Dynamic vs Cued Surveys
  - See Decision Tree: WS 17

Performance Testing?



What's the Detection Limit?
What Does It Mean?

Key Worksheets for “The Plan”



Measurement Performance Criteria: WS #12

- Criteria that collected data must meet to satisfy the DQOs.
- Failure impacts end uses of the data.

Design / Workflow: WS #17 and Schedule for DFW: WS #14-16

- Criteria that collected data must meet to satisfy the DQOs.
- Failure impacts end uses of the data.

Testing, Inspection and QC: WS #22

- Defines Specific Acceptance Criteria for each test.
- Failure response and root cause analysis for each MPC, each phase.

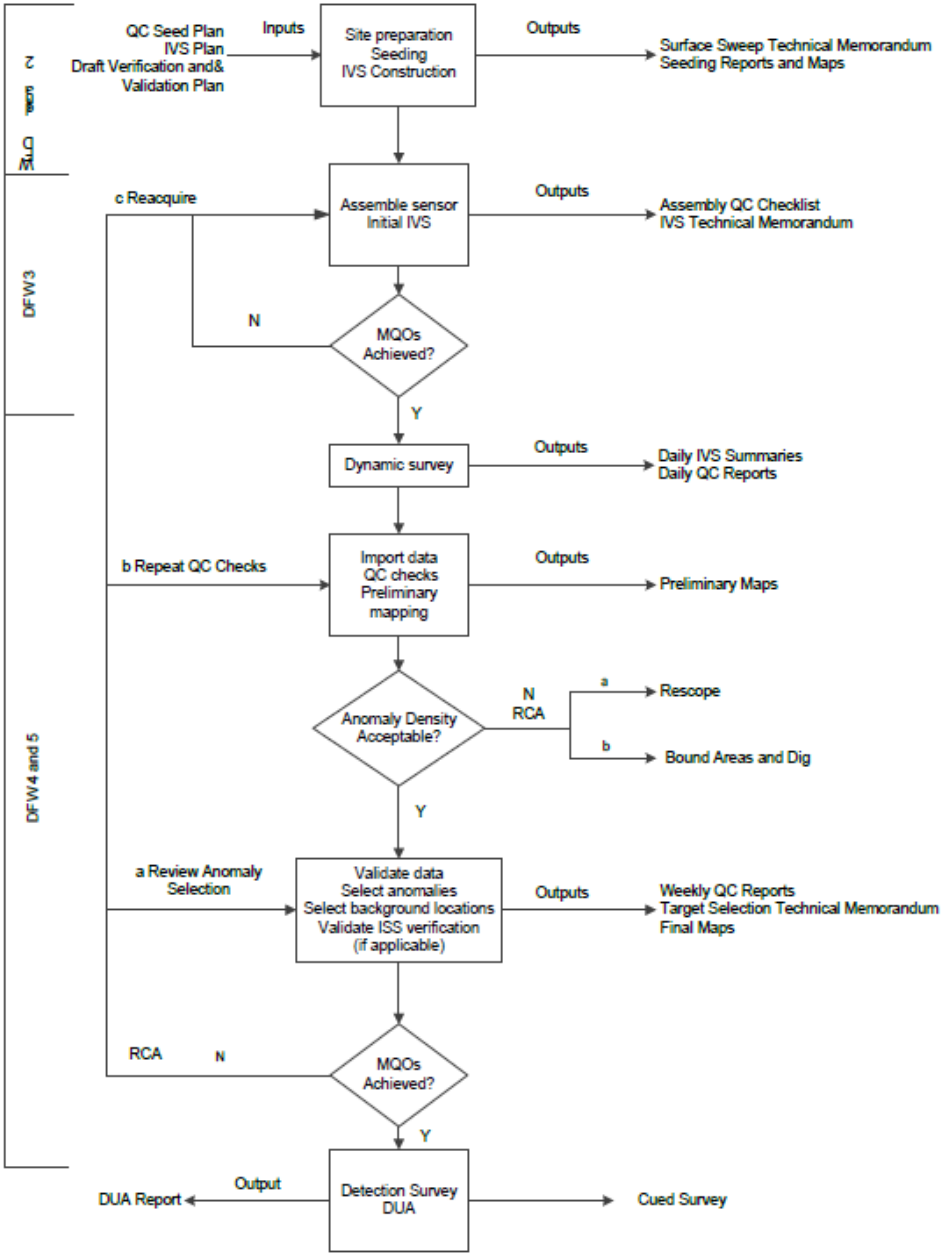
*DFW= definable features of work

WS #12: Measurement Performance Criteria - Detection

Measurement Performance Activity (or DFW)	Data Quality Indicator	Specification	Activity Used to Assess Performance
QC Seeding	Representativeness	Blind QC seeds will be placed at the site by the contractor. Blind QC seeds must be detectable as defined by the DQOs and located throughout the horizontal and vertical survey boundaries defined in the DQOs. [The blind seed plan should describe the number and types of blind QC seeds.] Blind QC seeds will be distributed such that the field team can be expected to encounter between one and three seeds per day per team.	Review of Production Area QC Seeding Report
Detection Survey	Completeness	100% of the site is sampled.	Verification of conformance to measurement quality objectives (MQOs) for in-line spacing and cross-line spacing (see Worksheet #22)
Detection survey	Sensitivity	This worksheet must describe the project-specific detection threshold. (Example) A detection threshold of .1.7 mV/A and SNR . 5 is required to detect a [37 mm projectile] lying horizontally at a depth of [0.3 m].	Initial and ongoing Instrument Verification strip (IVS) surveys Blind QC and validation seed detection Analysis of background variability across the site
Detection survey	Accuracy/ Completeness	100% of validation seeds must be detected.	Review of validation seed detection results per survey unit
Detection survey	Completeness/ Comparability	Complete project-specific databases and target lists delivered.	Data verification/data validation

Figure 17-1: Advanced Geophysical Classification Decision Tree

Preliminary Tasks and Anomaly Detection Survey



WS #17: Design

Work Flow Decision Tree

Preliminary Tasks & Detection Survey

WS #22: Testing, Inspection and QC - Detection

Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/ Report Method/Verified by	Acceptance Criteria	Failure Response
Verify correct assembly		Once following assembly	Field Team Leader/instrument assembly checklist/Project	As specified in Assembly checklist	RCA/CA: Make necessary
Initial Instrument Function Test (TEMTADS) (Instrument response amplitudes)		Once following assembly	Field Geophysicist/ Initial IVS Memorandum/ Project Geophysicist	Response (mean static spike minus mean static background) within 20% of predicted response for all transmit/receive (Tx/Rx) combinations	RCA/CA: Make necessary adjustments, and re-verify
Initial Instrument Function Test (MetalMapper) (five measurements over a small ISO80 target, one in each quadrant of the sensor and one directly under the center of the array). Derived polarizabilities for each measurement are compared to the library.		Once following assembly	Field Team Leader/ Instrument Assembly Checklist/ Project Geophysicist	Library match metric ≥ 0.95 for each of the five sets of inverted polarizabilities	RCA/CA: Make necessary adjustments, and re-verify
Initial Instrument Function Test (EM61)		Once following assembly	Field Geophysicist/ Initial IVS Memorandum/ Project Geophysicist	Response (mean static spike minus mean static background) within 20% of predicted response for all channels	RCA/CA: Make necessary adjustments, and re-verify
Initial detection survey positioning accuracy (IVS) [NAOC 101)		Once prior to start of detection survey data acquisition	Project Geophysicist/ IVS Memorandum/QC Geophysicist	Derived positions of IVS target(s) are within 25cm of the ground truth locations	RCA/CA: Make necessary adjustments, and re-verify

WS #22 (continued- detection)

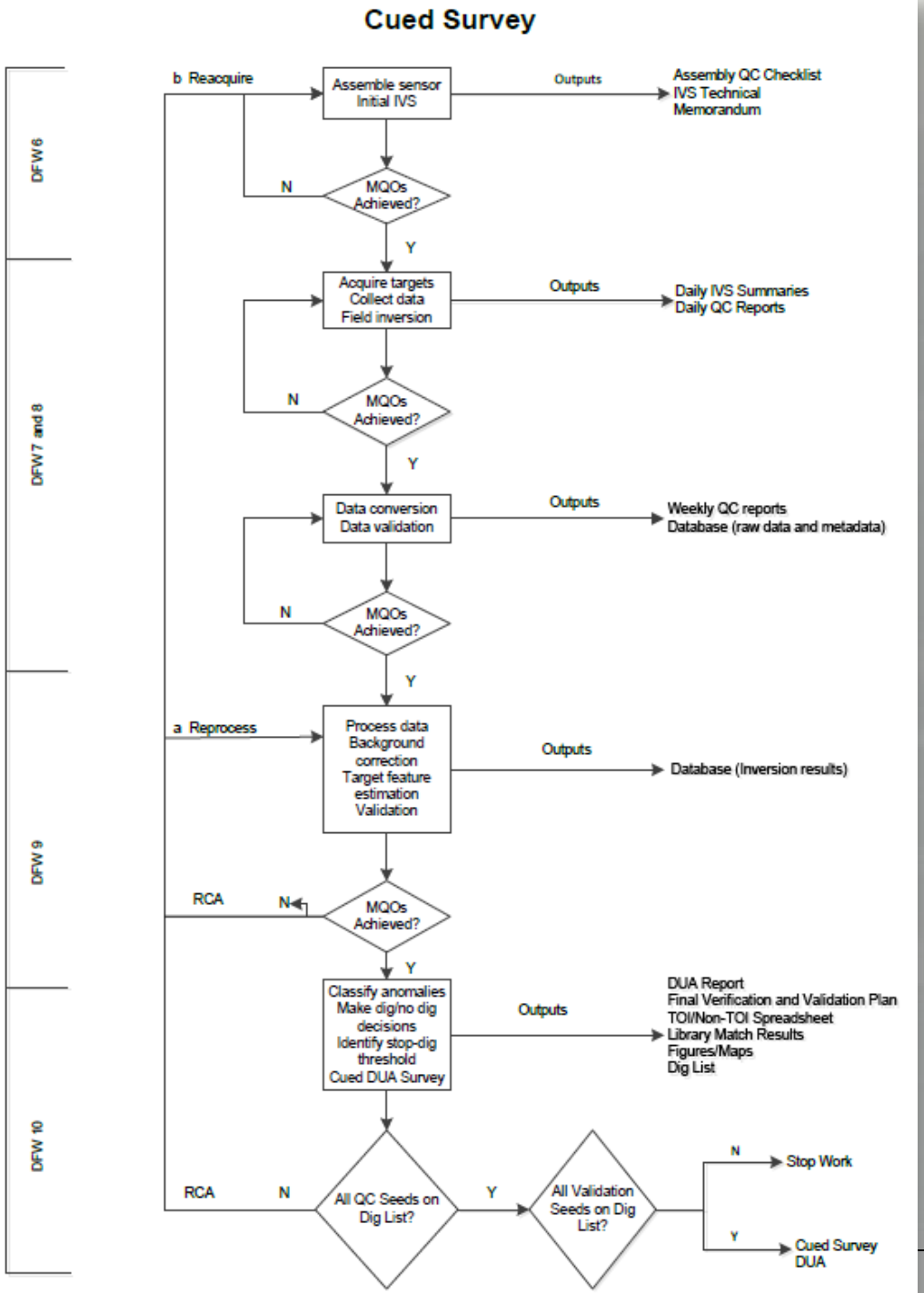
Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/ Report Method/ Verified by	Acceptance Criteria	Failure Response
Ongoing Instrument Function Test (EM61)		Beginning and end of each day and each time instrument is turned on	Field Team Leader/ running QC summary/Project or QC Geophysicist	Response (mean static spike minus mean static background) within 20% of predicted response for all channels	CA: Make necessary repairs and re-verify
Ongoing dynamic positioning precision (IVS)		Beginning and end of each day	Project Geophysicist / running QC summary/QC Geophysicist	Derived positions of IVS target(s) within 25 cm of the average locations	RCA/CA
In-line measurement spacing (TEMTADS)		Verified for each survey unit using [describe tool to be used] based upon monostatic Z coil data positions	Project Geophysicist/ running QC summary/ QC Geophysicist	100% ≤ 0.20m between successive measurements	RCA/CA CA assumption: data set fails, (recollect portions that fail)
In-line measurement spacing (MetalMapper)		Verified for each survey unit using [describe tool to be used] based upon monostatic Z coil data positions	Project Geophysicist/ running QC summary/ QC Geophysicist	100% ≤ 0.25m between successive measurements	RCA/CA
In-line measurement spacing (EM61)		Verified for each survey unit using [describe tool to be used] based upon monostatic Z coil data positions	Project Geophysicist/ running QC summary/ QC Geophysicist	100% ≤ 0.25m between successive measurements	RCA/CA

What SOPs?

- Instrument Assembly
- Setup/Continued Testing
  - ▶ Processing procedures
  - ▶ How is it tested/calibrated?
    - Background Tests
    - Instrument Verification Strip (IVS)
      - ▷ Initial Calibration
    - Continued Testing (QC)
      - ▷ QC Seeds
    - Quality Systems Test (QA)
      - ▷ QA Seeds
- Data Use

WS #12: Measurement Performance Criteria – Cued Survey

Measurement Performance Activity (or DFW)	Data Quality Indicator	Specification	Activity Used to Assess Performance
Classification survey	Completeness/ Comparability	Library must include signatures for all munitions known or suspected to be present at the site, as listed in the CSM.	Verification of site-specific library
Classification survey	Representativeness/ Accuracy	Background data will be collected at least once every two hours of cued survey data collection. Background locations will be selected such that background data will be representative of the various subsurface conditions expected to be encountered within each survey unit at the site.	Data verification/data validation
Classification survey	Completeness	All detected anomalies classified as: 1. TOI 2. Non TOI 3. Inconclusive	Data verification
Classification survey	Accuracy/ Completeness	Cued survey must correctly classify 100% of all validation seeds.	Review of validation seed classification results
Classification survey	Accuracy	100% of predicted non-TOI that are intrusively investigated are confirmed to be non-TOI.	Visual inspection of recovered items from classification validation



WS #17: Design

Work Flow Decision Tree

Cued Survey

WS #22: Testing, Inspection and QC - Cued

Table 22-2: Cued Survey (instrument: _____; classification tool: _____)

Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/ Report Method/ Verified by:	Acceptance Criteria	Failure Response
Verify correct assembly		Once following assembly	Field Team Leader/ instrument assembly checklist/Project Geophysicist	As specified in instrument assembly checklist	RCA/CA: Make necessary adjustments, and re-verify
Initial sensor function test (TEMTADS)		Once following assembly	Field Team Leader/ instrument assembly checklist/Project Geophysicist	Response (mean static spike minus mean static background) within 20% of predicted response for all Tx/Rx combinations	RCA/CA: make necessary repairs/ adjustments and re-verify
Initial instrument function test (MetalMapper) (five measurements over a small ISO80 target, one in each quadrant of the sensor and one directly under the center of the array). Derived polarizabilities for each measurement are compared to the library		Once following assembly	Field Team Leader/ instrument assembly checklist/ Project Geophysicist	Library match metric ≥ 0.95 for each of the five sets of inverted polarizabilities	RCA/CA: make necessary repairs/ adjustments and re-verify

WS #22: Testing, Inspection and QC - Cued

Table 22-2: Cued Survey (instrument: _____; classification tool: _____)

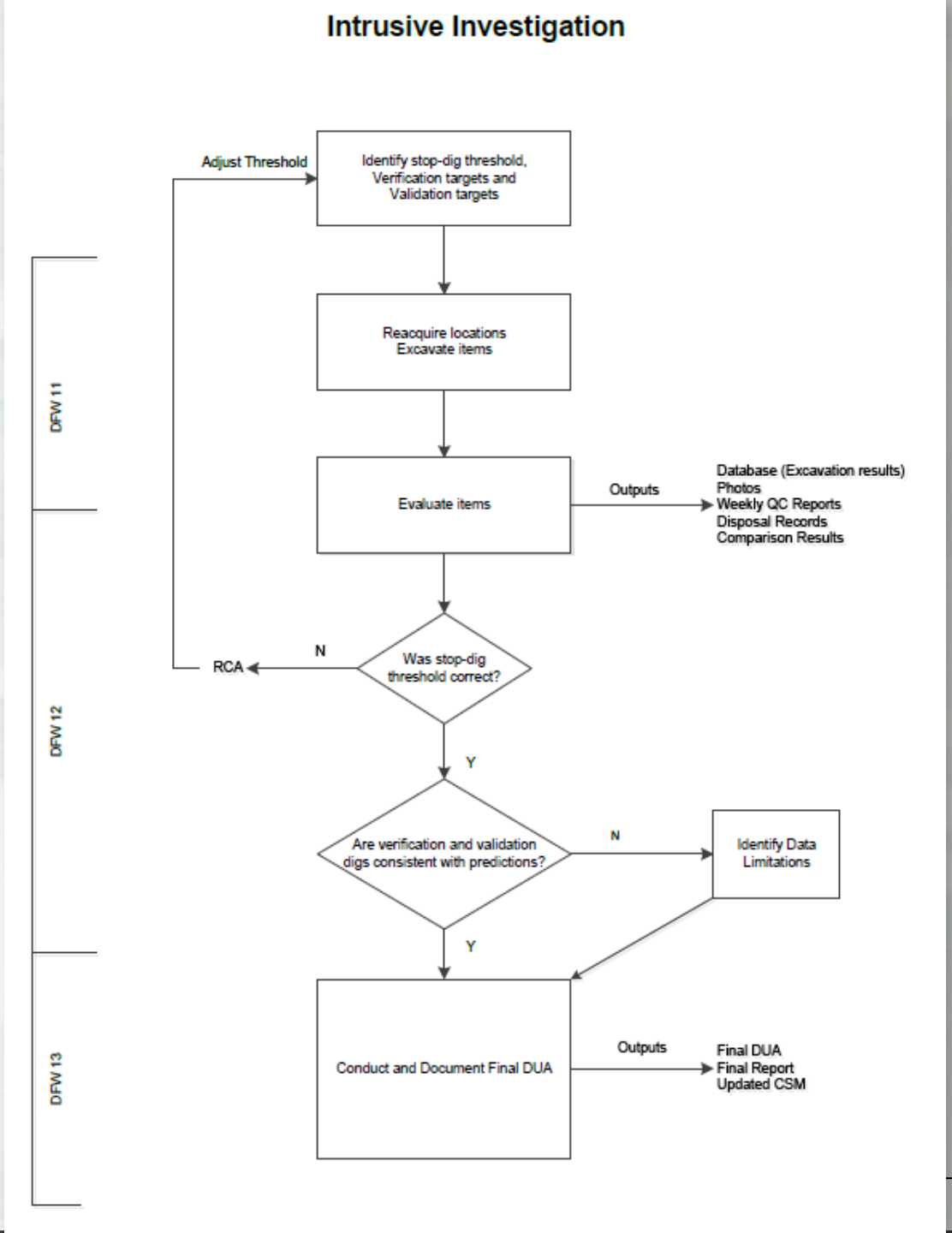
Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/ Report Method/ Verified by:	Acceptance Criteria	Failure Response
Initial IVS background measurement and background verification (five background measurements, one centered at the flag and one offset at least ½ sensor spacing in each cardinal direction)		Once during initial system IVS test	Field Team Leader/ Initial IVS memorandum/ Project Geophysicist	All five measurements (decay amplitude) within the noise level of each other and library match from all four offset measurements >0.9	RCA/CA: reject/replace BG location
Initial derived polarizabilities accuracy (IVS)		Once during initial system IVS test	Project Geophysicist/ Initial IVS memorandum/ QC Geophysicist	Library Match metric ≥ 0.9 for each set of inverted polarizabilities	RCA/CA
Derived target position accuracy (IVS)		Once during initial system IVS test	Project Geophysicist/ Initial IVS Memorandum/QC Geophysicist	All IVS item fit locations within 0.25m of ground truth locations	RCA/CA
Ongoing derived polarizabilities precision (IVS)		Beginning and end of each day as part of IVS testing	Project Geophysicist/ tracking summary/QC Geophysicist	Library Match to initial polarizabilities metric ≥ 0.9 for each set of three inverted polarizabilities	RCA/CA
Ongoing derived target position precision (IVS)		Beginning and end of each day as part of IVS testing	Project Geophysicist/ tracking summary/QC Geophysicist	All IVS items fit locations within 0.25m of average of derived fit locations	RCA/CA

WS #22 (continued- cued)

Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/ Report Method/ Verified by:	Acceptance Criteria	Failure Response
Ongoing instrument function test (MetalMapper)		Each time instrument is turned on	Field Team Leader/ tracking summary/ Project Geophysicist	Response within 20% of predicted response	CA: Make necessary repairs and re-verify
Transmit current levels (TEMTADS)		Evaluated for each sensor measurement	Field Team Leader/ tracking summary/ Project Geophysicist	Current must be ≥5.5A	CA: stop data acquisition activities until condition corrected
Transmit current levels (MetalMapper)		Evaluated for each sensor measurement	Field Team Leader/ tracking summary/ Project Geophysicist	Current must be ≥3.5A	CA: stop data acquisition activities until condition corrected
Confirm all background measurements are valid		Evaluated for each background measurement	Project Geophysicist/ Background summary/ QC Geophysicist	Ensure background variation does not impact ability to classify correctly	CA: BG measurement rejected and removed from active BG measurements
Confirm adequate spacing between units (TEMTADS)		Evaluated at start of each day (or grid)	Field Team Leader/ Field Logbook/ Project Geophysicist	Minimum separation of 50m	CA: Recollect all coincident measurements
Confirm adequate spacing between units (MetalMapper)		Evaluated at start of each day (or grid)	Field Team Leader/ Field Logbook/ Project Geophysicist	Minimum separation of 25m	CA: Recollect all coincident measurements
Confirm inversion model supports classification (1 of 3)		Evaluated for all models derived from a measurement (i.e. single item and multi-item models)	Project Geophysicist/ Measurement QC summary/ QC Geophysicist	Derived model response must fit the observed data with a fit coherence ≥ 0.8[6]	Follow procedure in SOP or RCA/CA
Confirm inversion model supports classification (2 of 3)		Evaluated for derived target	Project Geophysicist/ Measurement QC summary/ QC Geophysicist	Fit location estimate of item ≤ 0.4m from center of sensor	Follow procedure in SOP or RCA/CA

WS #12: Performance Criteria - Intrusive

Measurement Performance Activity (or DFW)	Data Quality Indicator	Specification	Activity Used to Assess Performance
Intrusive Investigation (classification validation)	Accuracy	Inversion results correctly predict one or more physical properties (e.g. size, symmetry, or wall thickness) of the recovered items (specific tests and test objectives established during project planning).	Visual inspection and qualitative evaluation of items recovered during classification validation
Intrusive Investigation	Completeness/ Comparability	Complete project-specific database including records reconciling inversion results to the physical properties of the recovered items.	Data Verification Data Validation



WS #17: Design

Work Flow Decision Tree

Intrusive Investigation

WS #22: Testing, Inspection and QC - Intrusive

Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/ Report Method/Verified by	Acceptance Criteria	Failure Response
Confirm derived features match ground truth (1 of 2)		Evaluated for all recovered items	Project Geophysicist/Measurement QC Summary or intrusive	100% of recovered (excluding inconclusive category) item positions ≤ 0.25m from predicted position (x,	RCA/CA
Confirm derived features match ground truth (2 of 2)		Evaluated for all recovered items	UXO Dig Team/ Dig List and intrusive database/Project or QC Geophysicist	100% of recovered object size estimates (excluding inconclusive category) qualitatively match	RCA/CA
Verification of TOI/non-TOI threshold		Dig 200 anomalies beyond last TOI on Dig List	Project Geophysicist/ Verification and Validation Report/QC	100% of predicted non-TOI intrusively investigated are non-TOI	RCA/CA. Adjust threshold
Classification validation		Random selection of 200 non-TOI	and Validation Report/ QC Geophysicist	qualitatively matches predicted size/shape	RCA/CA. Document in DUA

Worksheets 14 &16

- Tabulate Project Tasks from Flow Diagram
  - Activity
  - Responsible Party
  - Planned Start Date
  - Planned Completion Date
  - Deliverable
  - Deliverable Due Date

Oversight and Assessment: WS #29

- Data Management Tasks
  - Documents to be Generated
  - Frequencies
  - All Record Location & Durations
  - Distributions

Field Team Generated & Reported

Oversight and Assessment: WS #31, (32 & 33)

- Assessment & Corrective Actions: WS #31
  - ▶ Assessment Type for
    - Preparation
    - Initial Setup
    - Ongoing
  - ▶ Responsible Party
    - For Review
  - ▶ Frequency
  - ▶ Assessment Deliverable
    - Checklist / Summary of Findings
  - ▶ Due Date

QC Reviewed & Reported

Oversight and Assessment: WS #31, (32 & 33)

- Assessment & Corrective Actions: WS #31
  - ▶ Assessment Type for
    - All Phases
  - ▶ Responsible Party for Response
  - ▶ Timeframe for Response
  - ▶ Responsible Party for Implementation of Corrective Action
  - ▶ Responsible Party for Oversight of Corrective Action
  - ▶ Due Date

QC Review Reponses

Verification, Validation and Usability Input WS #34

- Verification
  - ▸ Completeness of tasks and data
- Validation
  - ▸ Conformance to Specifications
- Usability
  - ▸ Achievement of MPCs
  - ▸ Overall Achievement of DQOs
    - Decision can be made with confidence

Identifies QA Review Inputs

Verification and Validation Procedures: WS #35

- Verification and Validation Reviews
  - Who is Responsible?
  - What is Reviewed?
  - When (Frequency)?
  - How Reported?

Lists QA Oversight Review and Reports

Detailed Validation Procedures: WS #36

- General Plan for QA
- How Thresholds are Tested
  - "Blind Validation" Seed Plan (Firewalled)
  - Verification of the "Threshold" for "Dig List"

Data Usability Assessment: WS #37

Requirements:

- Performed by "key members" of the PDT
- Completed at conclusion of each phase of investigation
  - Delivery Units

Review:

- SPP in Retrospect
- Support Assumptions
  - CSM
  - Managed Uncertainty
- Representative Data
- Confidence in Data

WS #37: Key Personnel and Delivery Unit

Key Personnel

- Project Manager
- QA Manager
- QA Geophysicist
- QC Geophysicist
- Field Geophysicist (Lead)

Delivery Unit (DU)

- Each (or grouped) Survey Units prepared as a data set for reporting.
  - Daily?
  - Weekly?
  - Bulk anomalies?

WS #37: Inputs to Usability

Usability Documents

- QAPP
  - Verification & Validation Plan
- QASP
- Contract
- QC Reports
- Corrective Actions
- IVS Memoranda

- Detection Survey Validation Report
- Site Specific Library
- Cued Survey Validation Report
- Prioritized Target “Dig” List
- Target Classification Report
- Classification Validation Report

WS #37: Process

Step 1.

- Review Objectives and Sampling Design
- Is Design Consistent with objectives?
- Identify Deviations

Step 2.

- Review Verification / Validation Inputs
- Evaluate Conformance to MPCs (WS #12)

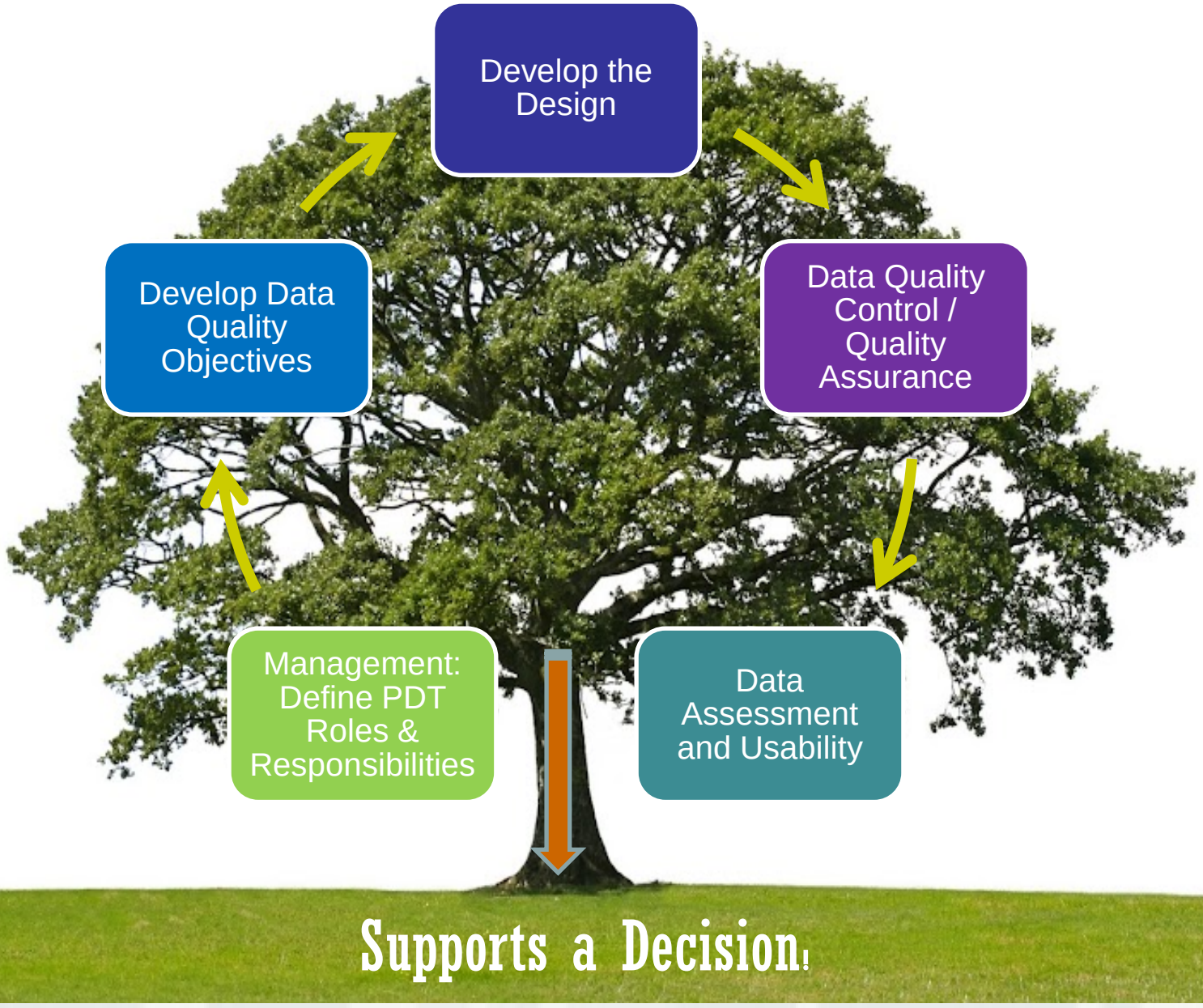
Step 3.

- Document Data Usability
  - Implications of missed QC and corrective actions
- Update CSM
- Draw Conclusions
  - Next Phase?

Step 4.

- Lessons Learned
- Recommendations for changes to DQOs in future DUs if needed.

Planning Complete!!!!

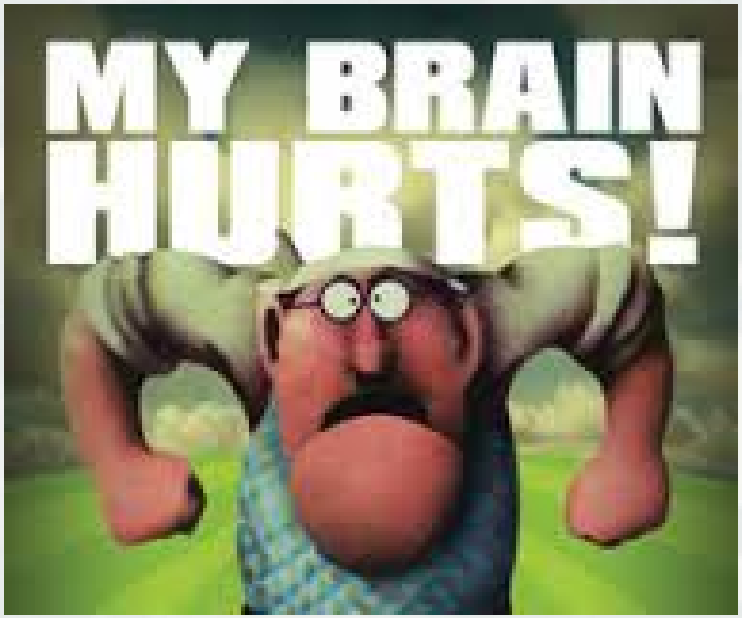


Questions?

John M. Jackson

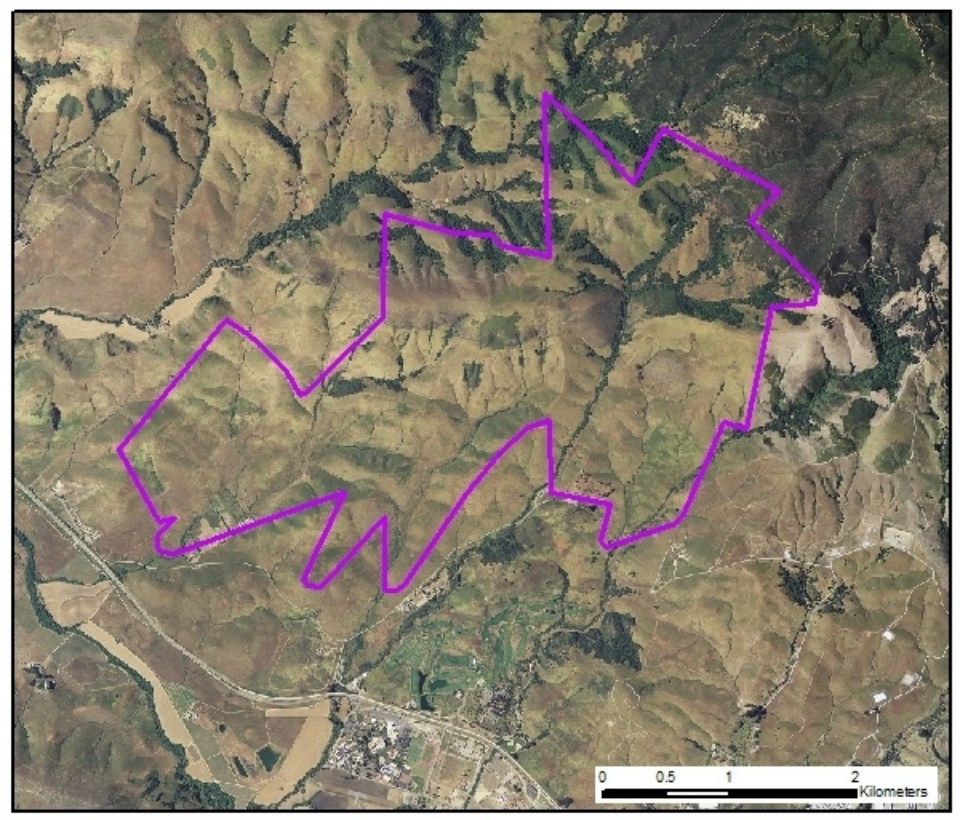
John.M.Jackson@usace.army.mil

(916) 557-6614



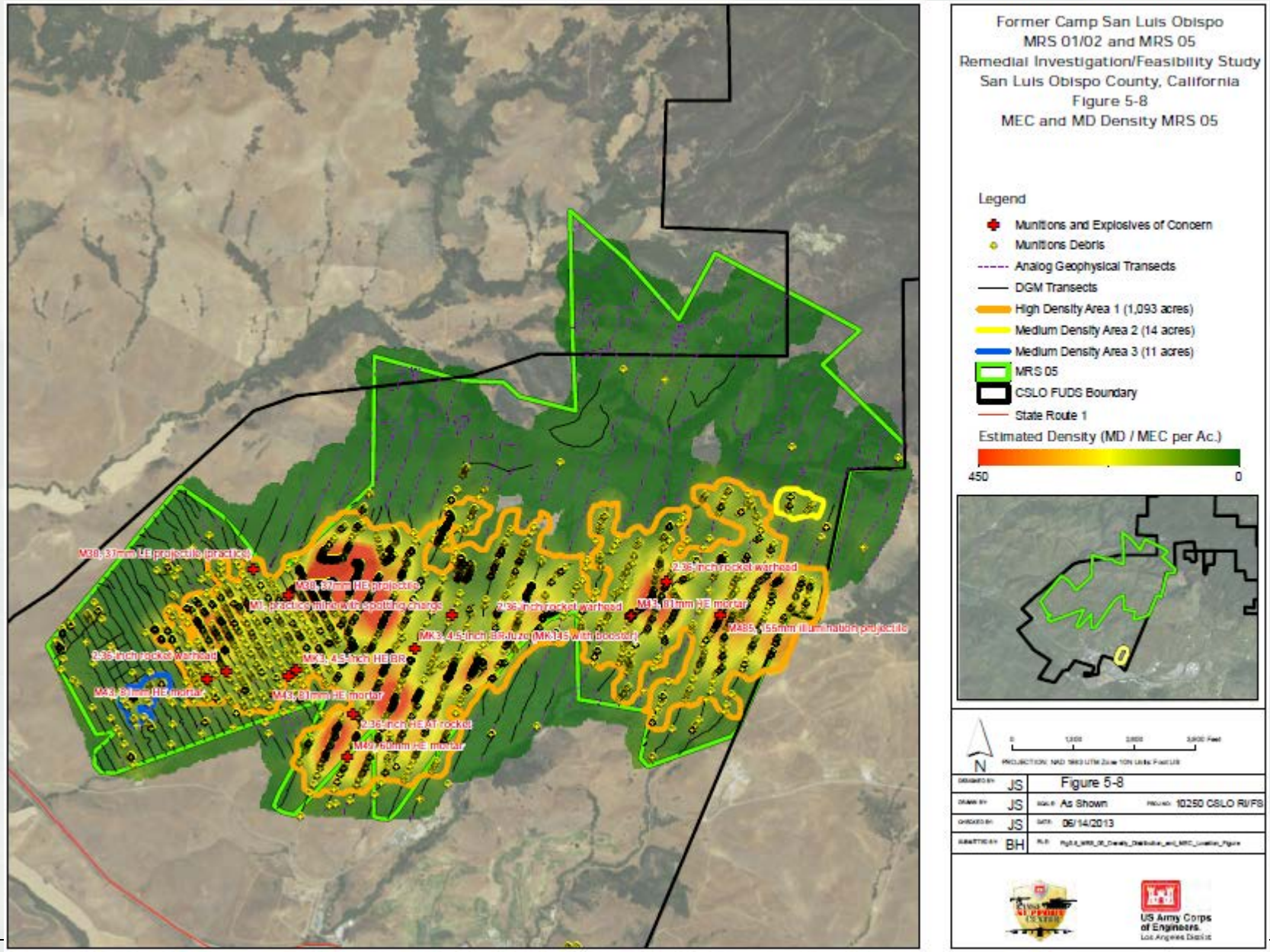
Group Exercise!!!

Remember Camp SLO?



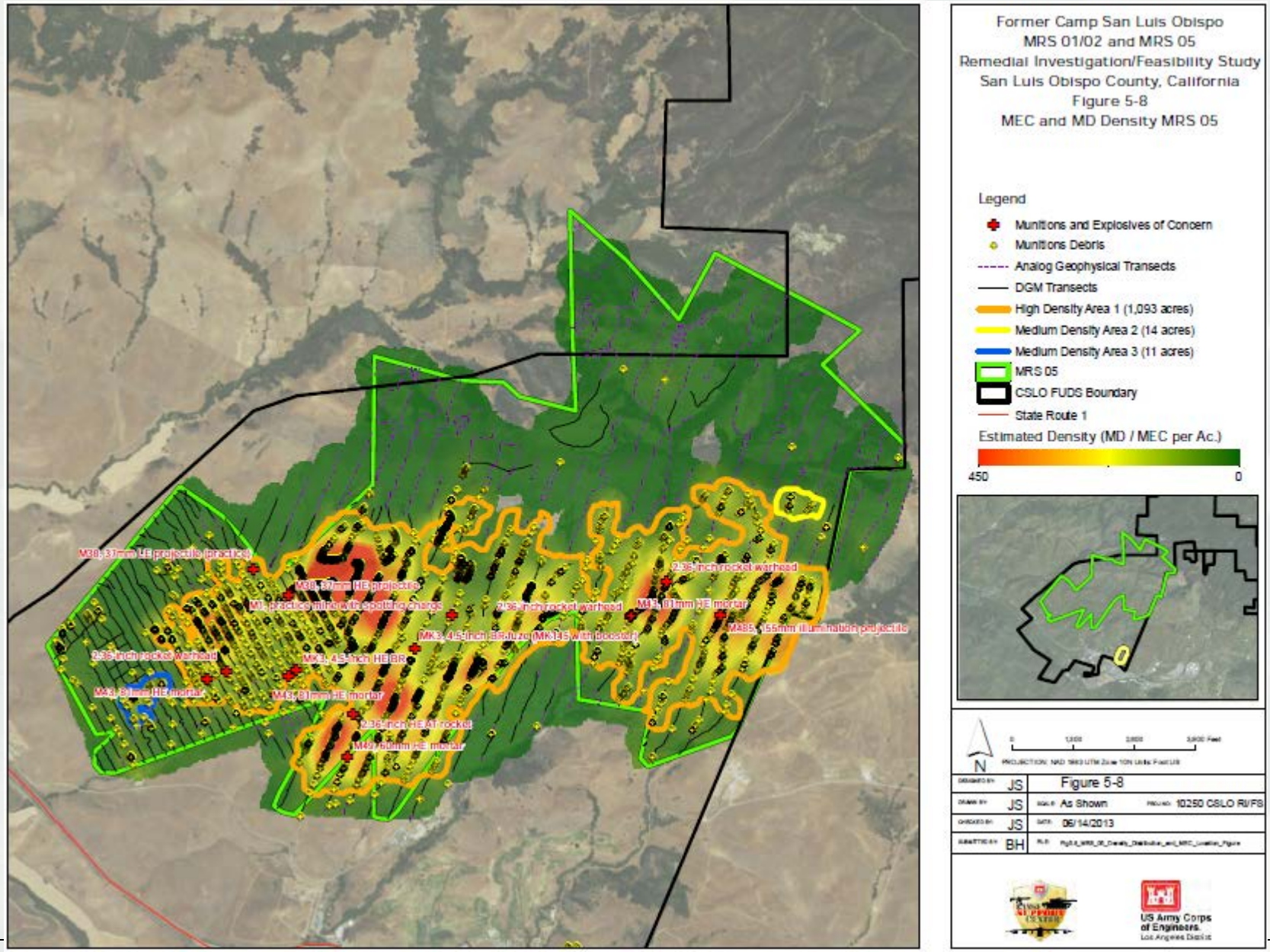
- University owned
  - ► No access restrictions
  - ► Cattle grazing
  - ► Geotechnical classes
  - ► Camping
- Multiple, overlapping range fans
- MRS ~ 2,500 acres

Former Camp SLO RI Results



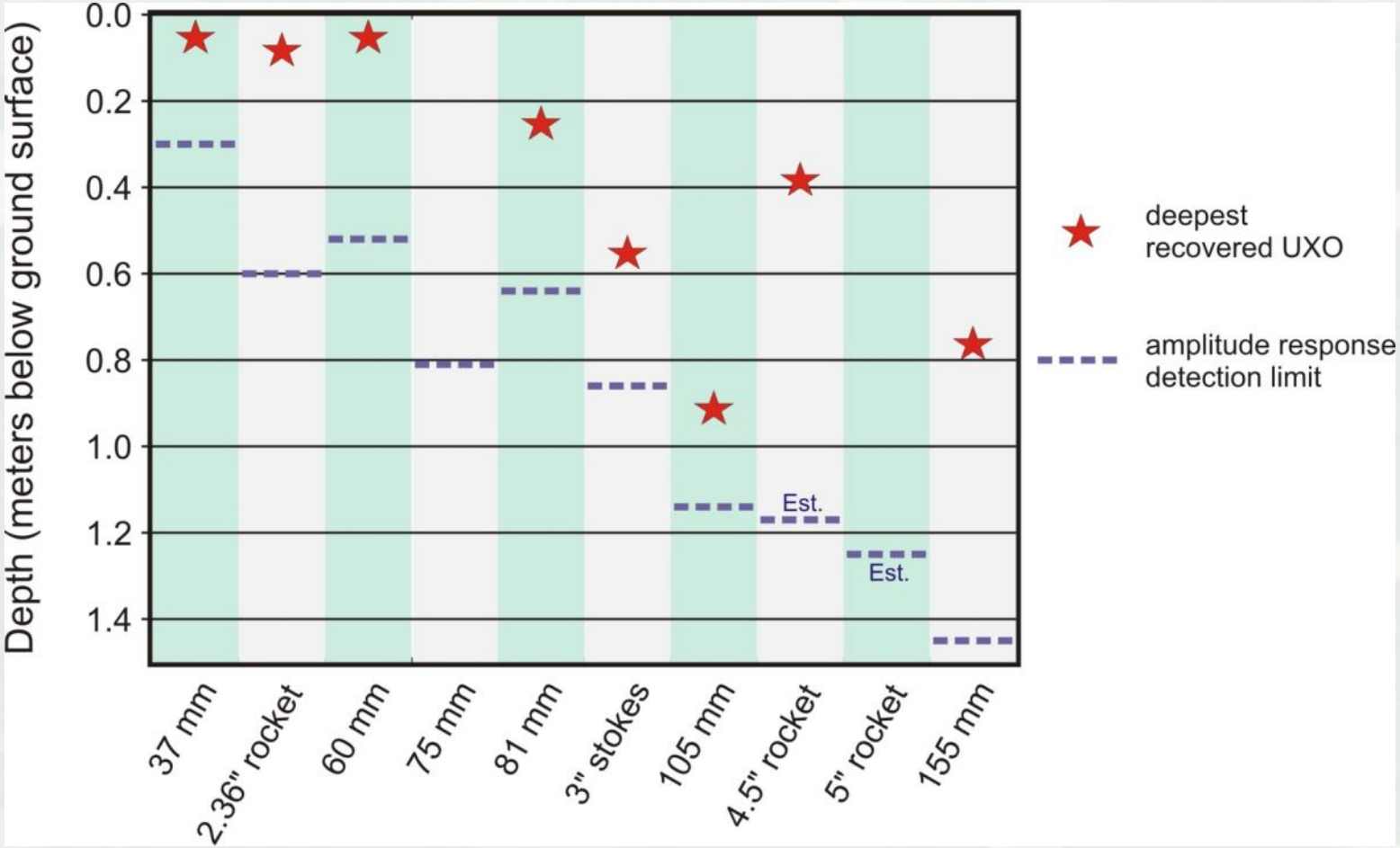
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Step 1- Delineate the site



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Step 2- Develop RAOs for each (sub)MRS



Step 3- Pick one MRS, create your DQO

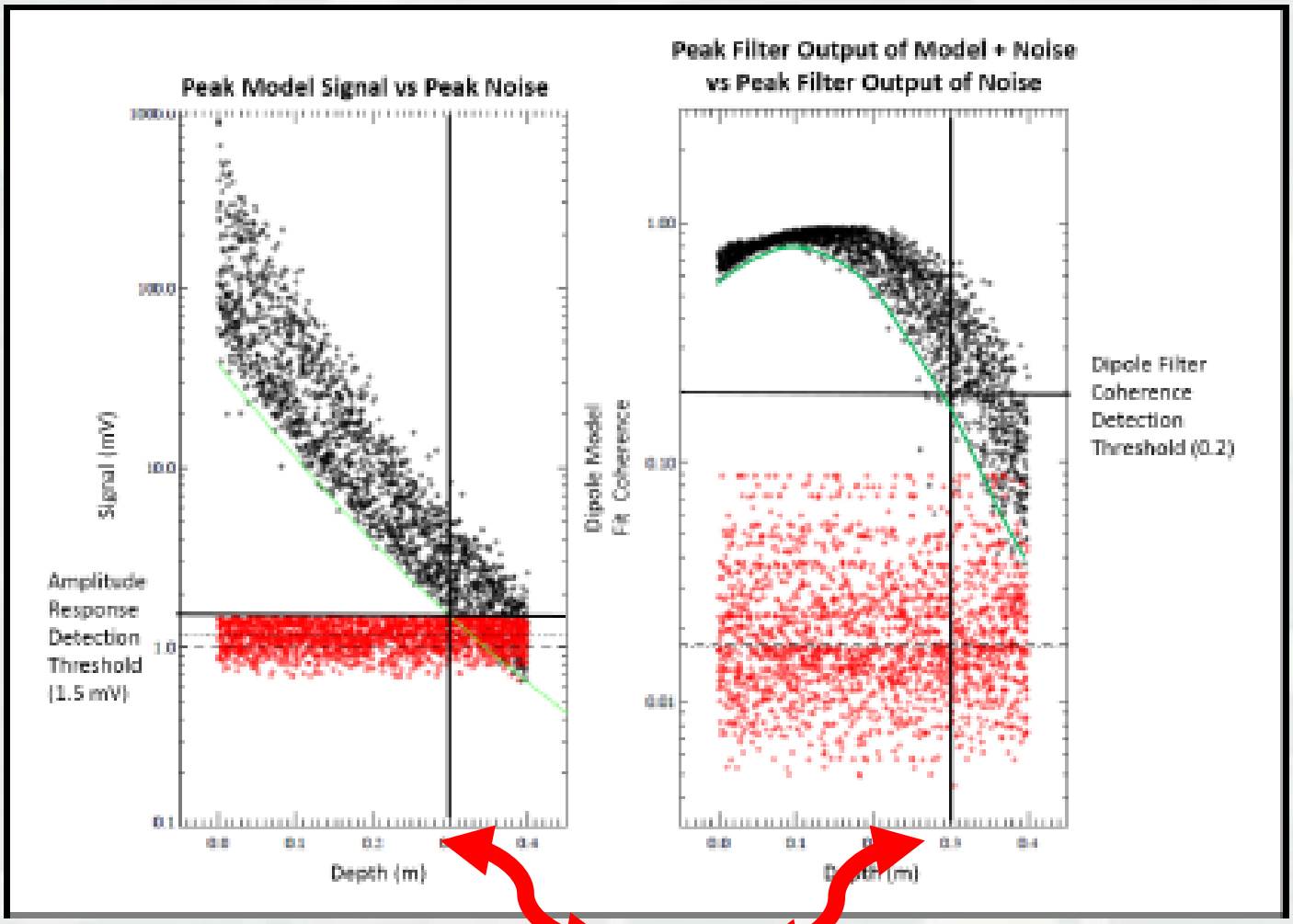
7-step Process

- Step 1: Problem Statement
- Step 2: Goals of the Study
- Step 3: Information Inputs
- Step 4: Boundaries
- Step 5: Analytic Approach
- Step 6: Performance Objectives
- Step 7: Detailed Plan to Obtain Data

Instructions

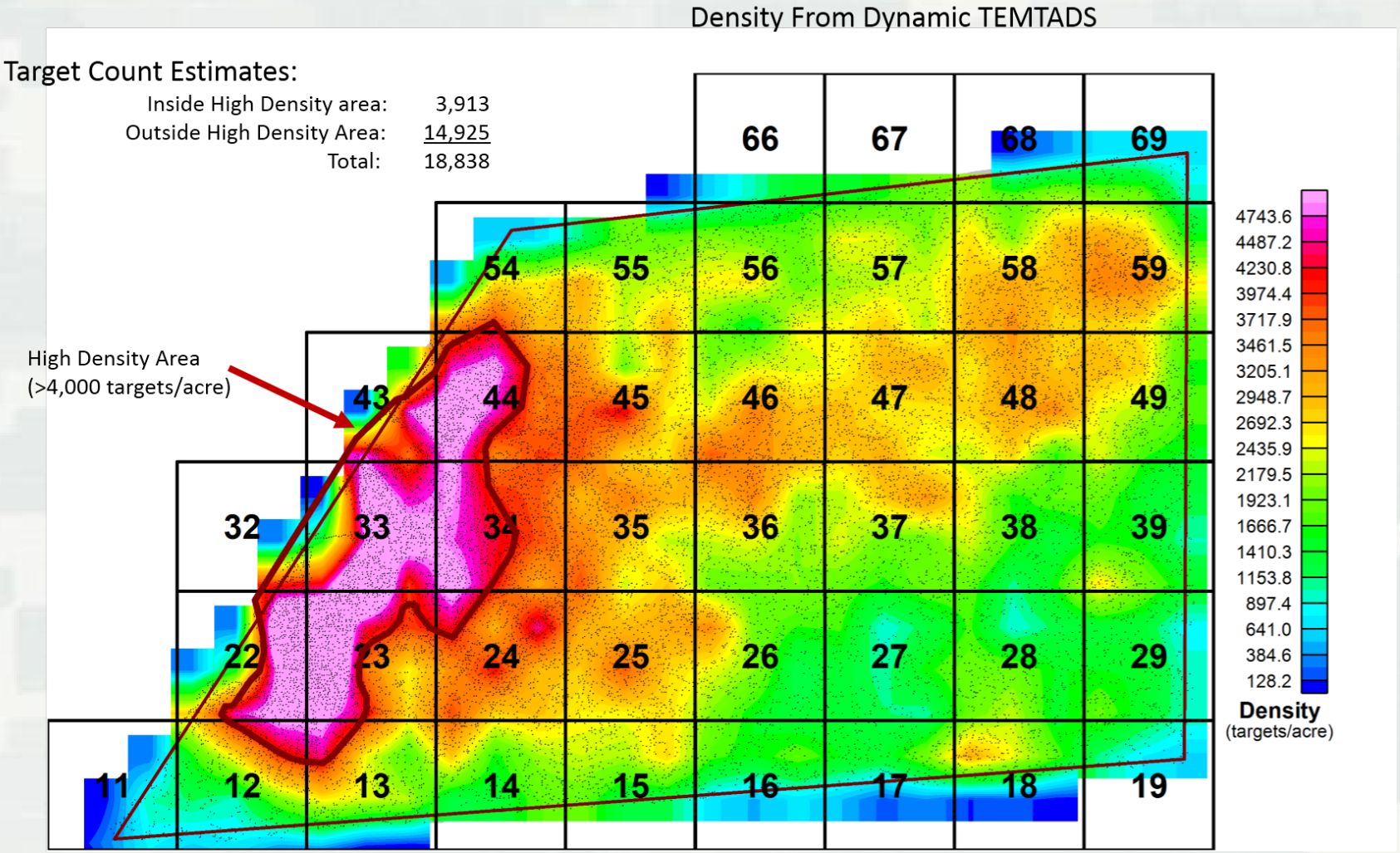
- Write a detailed problem statement
- Provide general statements or ideas for the other 6 steps

Post Remedy- Scenario 1

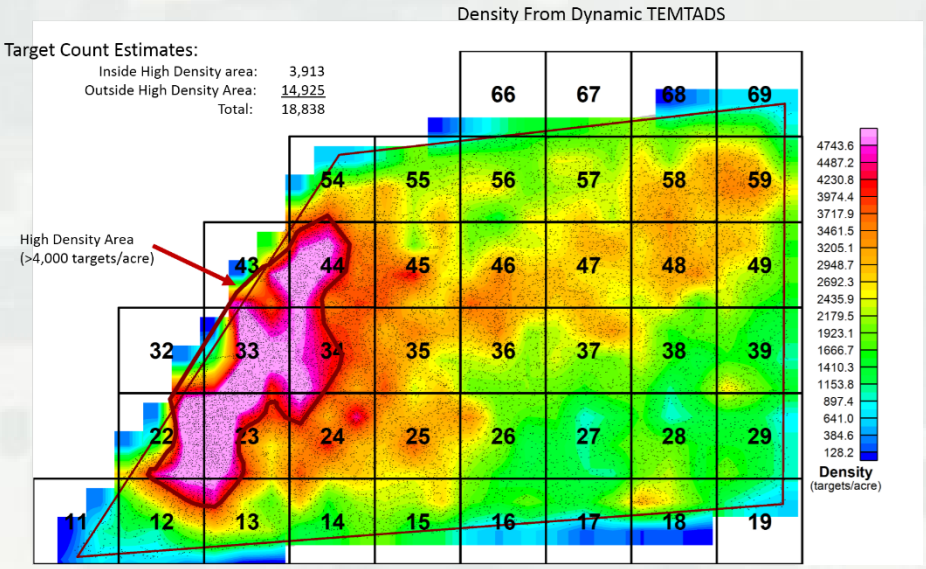


1 foot

Scenario 1- High density not completed- data gap



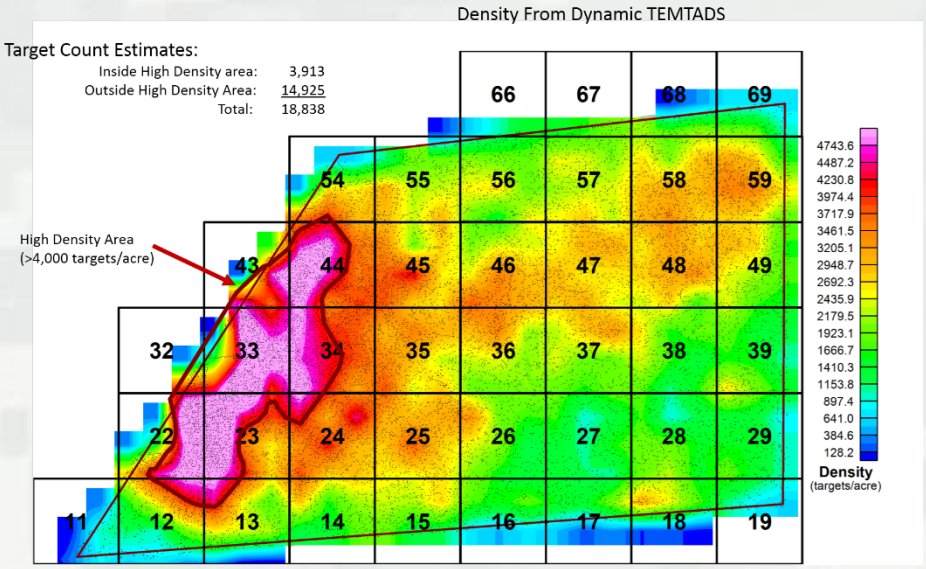
Scenario 1- High density not completed- data gap



Questions

- Did we meet the RAO and intent of the ROD?
- ROD requires explanation of significant differenced?
  - What would the ESD look like?
- LUCs?
  - How do we implement on state lands?
  - How do we implement on private lands?

Scenario 2- High density completed- NO data gap



Questions

- Did we meet the RAO and intent of the ROD?
- ROD requires explanation of significant differenced?
  - What would the ESD look like?
- LUCs?
  - How do we implement on state lands?
  - How do we implement on private lands?

Scenario 3- Dig results comparison

3a

Anomaly/Target Quantities Amplitude Response Anomalies Detected	16,202
Advanced Detection Analysis Targets (Potential TOI Identified for Cued Analysis)	7,035
Targets Identified for Dig List	753
Can't Analyze	(104)
Potential TOI	(418)
Calibration, Threshold Verification and Validation Digs	(231)
Dig Records in Database (more than one item found within a 0.4 meter radius resulted in multiple records for an investigated location)	1,456
Munitions Debris (note that some of the individual records indicate multiple pieces of frag)	(1,223)
QC or QA Seed	(94)
Other Debris (Primarily Scrap Metal)	(62)
Small Arms	(36)
No Contact	(36)
Other (shared with adjacent anomaly)	(4)
UXO	(1)

3b

Anomaly/Target Quantities Amplitude Response Anomalies Detected	16,202
Advanced Detection Analysis Targets (Potential TOI Identified for Cued Analysis)	7,035
Targets Identified for Dig List	753
Can't Analyze	(104)
Potential TOI	(418)
Calibration, Threshold Verification and Validation Digs	(231)
Dig Records in Database (more than one item found within a 0.4 meter radius resulted in multiple records for an investigated location)	1,456
Munitions Debris (note that some of the individual records indicate multiple pieces of frag)	(1,223)
QC or QA Seed	(94)
Other Debris (Primarily Scrap Metal)	(62)
Small Arms	(36)
No Contact	(36)
Other (shared with adjacent anomaly)	(4)
UXO	(38)

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Scenario 4- verification/validation

4a

Anomaly/Target Quantities Amplitude Response Anomalies Detected	16,202
Advanced Detection Analysis Targets (Potential TOI Identified for Cued Analysis)	7,035
Targets Identified for Dig List	553
Can't Analyze	(104)
Potential TOI	(418)
Calibration, Threshold Verification and Validation Digs	(31)
Dig Records in Database (more than one item found within a 0.4 meter radius resulted in multiple records for an investigated location)	1,456
Munitions Debris (note that some of the individual records indicate multiple pieces of frag)	(1,223)
QC or QA Seed	(14)
Other Debris (Primarily Scrap Metal)	(62)
Small Arms	(36)
No Contact	(36)
Other (shared with adjacent anomaly)	(4)
UXO	(1)

4b

Anomaly/Target Quantities Amplitude Response Anomalies Detected	16,202
Advanced Detection Analysis Targets (Potential TOI Identified for Cued Analysis)	7,035
Targets Identified for Dig List	2753
Can't Analyze	(2104)
Potential TOI	(418)
Calibration, Threshold Verification and Validation Digs	(231)
Dig Records in Database (more than one item found within a 0.4 meter radius resulted in multiple records for an investigated location)	1,456
Munitions Debris (note that some of the individual records indicate multiple pieces of frag)	(1,223)
QC or QA Seed	(94)
Other Debris (Primarily Scrap Metal)	(62)
Small Arms	(36)
No Contact	(36)
Other (shared with adjacent anomaly)	(4)
UXO	(38)

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ACCREDITATION

Advanced Geophysical Classification (AGC)

US Army Corps of Engineers

U.S.ARMY

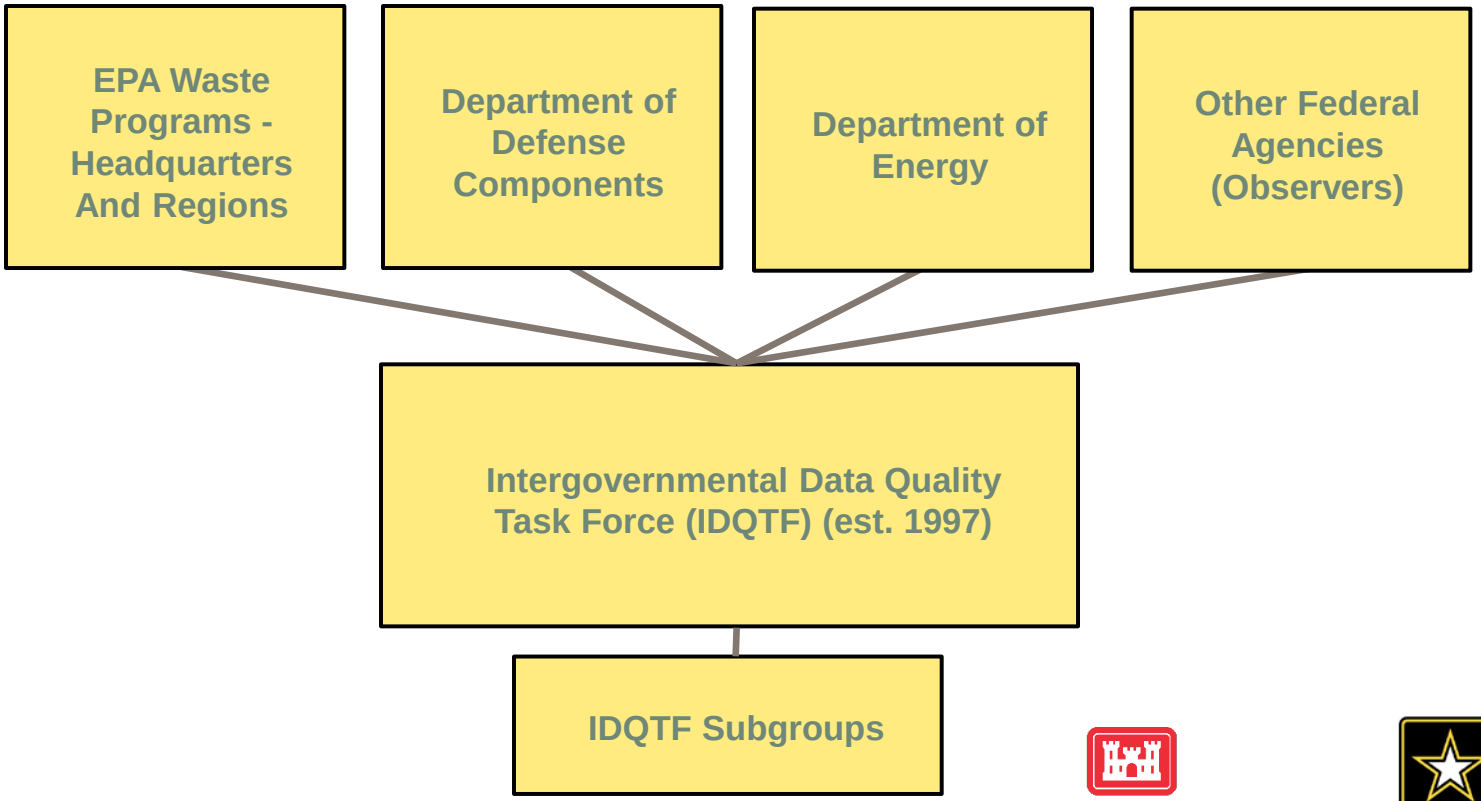
AGC PROCESS IN REVIEW
THE PROCESS IS LINEAR

- The AGC process consists of three steps:
  1. Measure the response of a subsurface metal object to an electromagnetic field using an advanced geophysical sensor.
  2. Analyze the measured response to determine target parameters such as depth, size, aspect ratio, and wall thickness.
  3. Use these parameters as inputs to a classifier to help decide whether the detected item is most likely a munition that must be investigated.

AGC PROCESS (AND DGM IN GENERAL) QUALIFIES AS ENVIRONMENTAL SAMPLING

Intergovernmental Data Quality Task Force

An interagency partnership with a shared mission and goals



US Army Corps of Engineers

U.S.ARMY

Mission

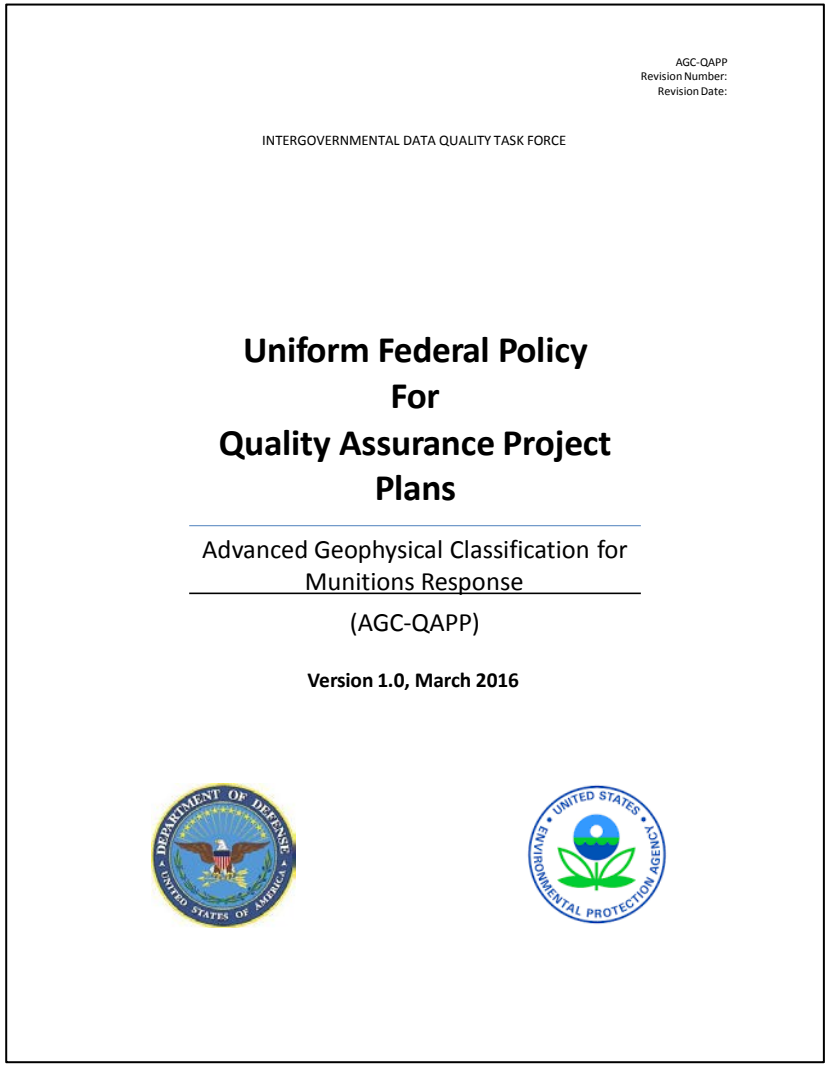
- To document an intergovernmental quality system, beginning with the hazardous waste programs (CERCLA and RCRA)

Goals

- To document an intergovernmental quality system based on ANSI/ASQC E-4
- To identify the roles and responsibilities of EPA and other Federal agencies regarding QA/QC oversight
- To develop guidance for implementing Federal Government-wide requirements and procedures regarding data quality

IDQTF PRODUCTS

Uniform Federal Policy for Implementing Environmental Quality Systems	Final, signed by all three agencies, January 2003
Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP), Manual and Workbook	Review draft, Fall 2003
QA/QC Compendium: Minimum QA/QC Activities	Review draft, Fall 2003
Roles and Responsibilities Guidance, Appendix to UFP-QS	Review draft, Spring 2004
AGC QAPP	Final, March 2016
MEC QAPP	Draft, 2016/2017



AGC-QAPP
Revision Number:
Revision Date:

INTERGOVERNMENTAL DATA QUALITY TASK FORCE

Uniform Federal Policy
For
Quality Assurance Project Plans

Advanced Geophysical Classification for Munitions Response

(AGC-QAPP)

Version 1.0, March 2016

UNIFORM FEDERAL POLICY FOR QUALITY ASSURANCE PROJECT PLANS – ADVANCED GEOPHYSICAL CLASSIFICATION FOR MUNITIONS RESPONSE (AGC-QAPP)

https://www.epa.gov/fedfac/uniform-federal-policy-quality-assurance-project-plans-template-advanced-geophysical

US Army Corps of Engineers

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COMMITMENT TO IDQTF PRODUCT

- Each agency will decide how best to implement products.
- Each agency will be responsible for its own oversight.
- IDQTF will have a continuing role to address issues and ensure improvement.

US Army Corps of Engineers

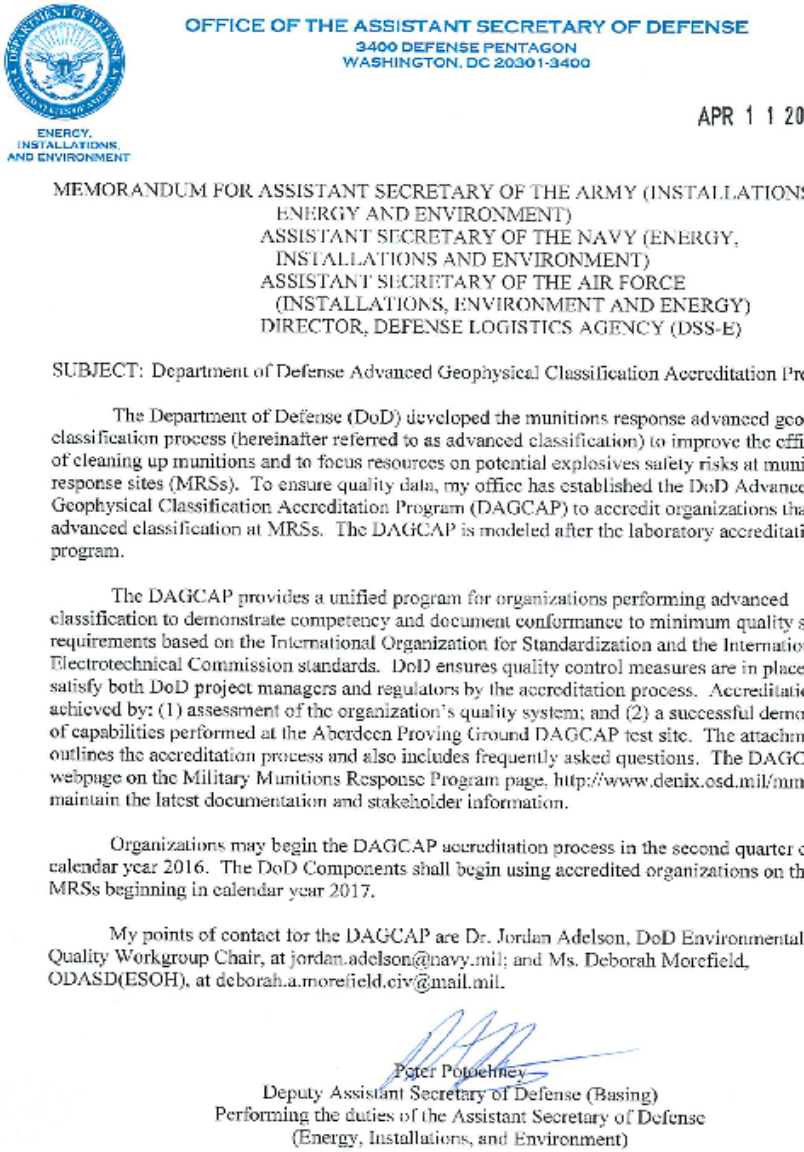
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AGC IMPLEMENTATION IN THE DOD

DAGCAP IS THE NEW NORMAL

DoD ADVANCED GEOPHYSICAL CLASSIFICATION ACCREDITATION PROGRAM (DAGCAP)

Memo signed April 11, 2016, established DAGCAP to accredit organizations that use AGC at MRSs.



OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE
3400 DEFENSE PENTAGON
WASHINGTON, DC 20301-3400

ENERGY, INSTALLATIONS, AND ENVIRONMENT

APR 1 1 2016

MEMORANDUM FOR ASSISTANT SECRETARY OF THE ARMY (INSTALLATIONS, ENERGY AND ENVIRONMENT)
ASSISTANT SECRETARY OF THE NAVY (ENERGY, INSTALLATIONS AND ENVIRONMENT)
ASSISTANT SECRETARY OF THE AIR FORCE (INSTALLATIONS, ENVIRONMENT AND ENERGY)
DIRECTOR, DEFENSE LOGISTICS AGENCY (DSS-E)

SUBJECT: Department of Defense Advanced Geophysical Classification Accreditation Program

The Department of Defense (DoD) developed the munitions response advanced geophysical classification process (hereinafter referred to as advanced classification) to improve the efficiency of cleaning up munitions and to focus resources on potential explosives safety risks at munitions response sites (MRSs). To ensure quality data, my office has established the DoD Advanced Geophysical Classification Accreditation Program (DAGCAP) to accredit organizations that use advanced classification at MRSs. The DAGCAP is modeled after the laboratory accreditation program.

The DAGCAP provides a unified program for organizations performing advanced classification to demonstrate competency and document conformance to minimum quality systems requirements based on the International Organization for Standardization and the International Electrotechnical Commission standards. DoD ensures quality control measures are in place to satisfy both DoD project managers and regulators by the accreditation process. Accreditation is achieved by: (1) assessment of the organization's quality system; and (2) a successful demonstration of capabilities performed at the Aberdeen Proving Ground DAGCAP test site. The attachment outlines the accreditation process and also includes frequently asked questions. The DAGCAP webpage on the Military Munitions Response Program page, http://www.denix.osd.mil/mmrp, will maintain the latest documentation and stakeholder information.

Organizations may begin the DAGCAP accreditation process in the second quarter of calendar year 2016. The DoD Components shall begin using accredited organizations on their MRSs beginning in calendar year 2017.

My points of contact for the DAGCAP are Dr. Jordan Adelson, DoD Environmental Data Quality Workgroup Chair, at jordan.adelson@navy.mil; and Ms. Deborah Morefield, ODASD(ESOH), at deborah.a.morefield.civ@mail.mil.

Peter Potochney
Deputy Assistant Secretary of Defense (Basing)
Performing the duties of the Assistant Secretary of Defense
(Energy, Installations, and Environment)

Attachment:
As stated

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DAGCAP OVERVIEW

- Modeled after DoD Environmental Laboratory Accreditation Program (ELAP)
- Third-party Accreditation Bodies (ABs) conduct assessments to Quality Systems Requirements (QSR)
- Applies to all testing organizations regardless of size or volume of business
- Applies to use of AGC at all MRSs

A STATE'S PERSPECTIVE ON ADVANCED GEOPHYSICAL CLASSIFICATION AND THE EVOLUTION OF MMRP

COPIED FROM:
2016 NATIONAL FUDS FORUM
AUGUST 2016

PRESENTED BY: TRACIE WHITE & JEFF SWANSON
COLORADO DEPARTMENT OF PUBLIC HEALTH & ENVIRONMENT

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BIG PICTURE – KEY IDEAS
ADVANCED SENSORS & GEOPHYSICAL CLASSIFICATION

Technology Acceptance & Adoption

- It works, really good!
- Not a “silver bullet”, not appropriate everywhere

Quality Systems is the key to success

- Accreditation is a game changer
- QAPP provides the quality framework
- Sustain with policy, training, and implementation

Implementation & Oversight

- Focus on decision points
- Classification is hands-on technology
- Requires active stakeholder participation

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CLASSIFICATION TECHNOLOGY

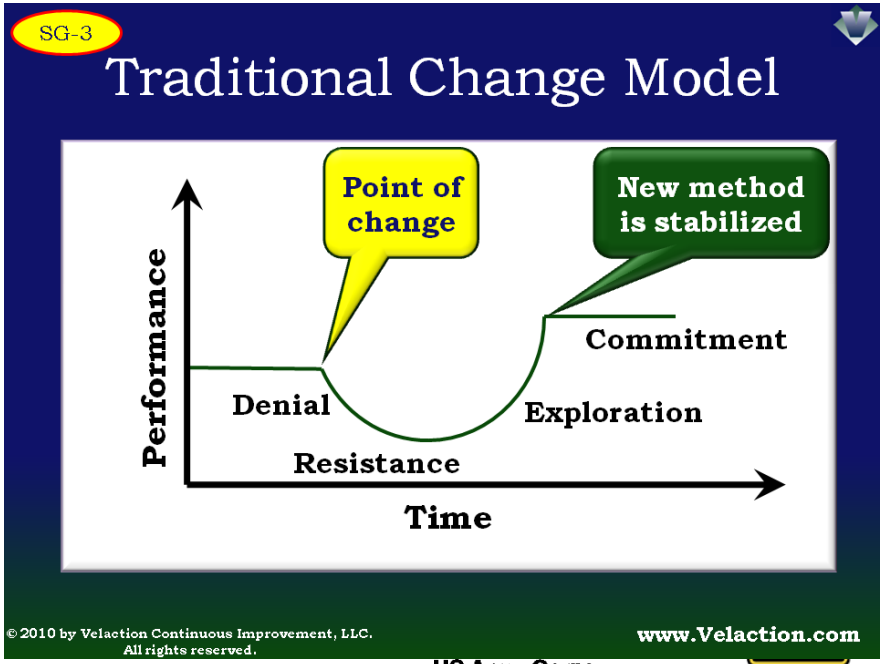
Classification is a disruptive technology

- Changing how munitions cleanup is conducted…
- Driving several important secondary changes…

Major changes

- Contracting
- Planning & Design
- Field Implementation
- Quality Systems
- Corps Oversight Role
- State Oversight Role

Touches all Stakeholders



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EVOLUTION OF MUNITIONS CLEANUP

Technology Gen 3

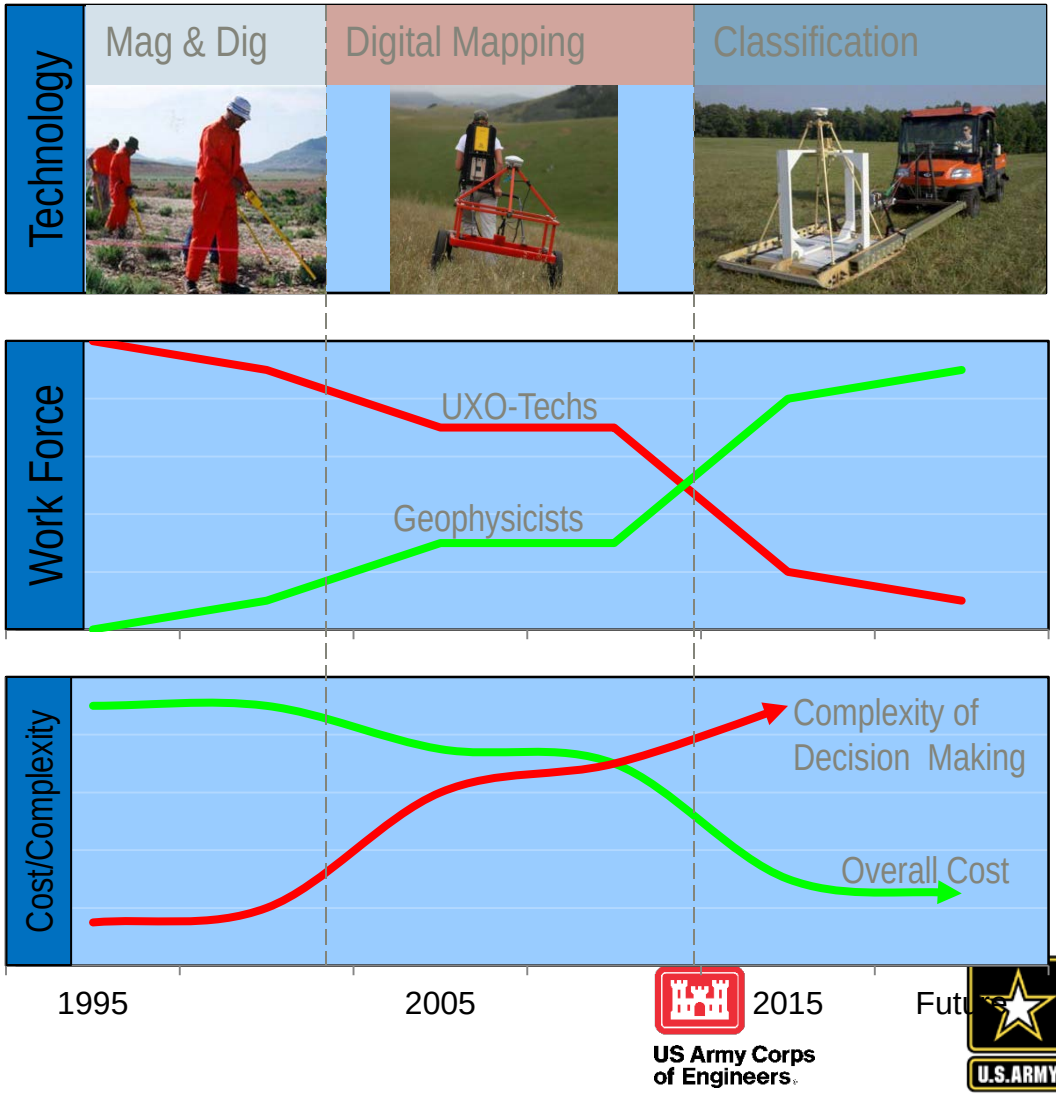
- Advanced sensors
- Classification decisions

Work Force

- Smaller work force
- Multiple field mobs
- Reduced digging cost

Cost & Complexity

- Significant cost savings
- Increased complexity of decision making
- New oversight & quality requirements



COLORADO'S EXPERIENCE

Former Lowry Bombing & Gunnery Range
Geophysical Classification Demonstration

Project Site

- 57mm Recoilless Rifle Range (GM MRS)
- 57mm, 37mm projectiles (20mm?)

Scope of Demo

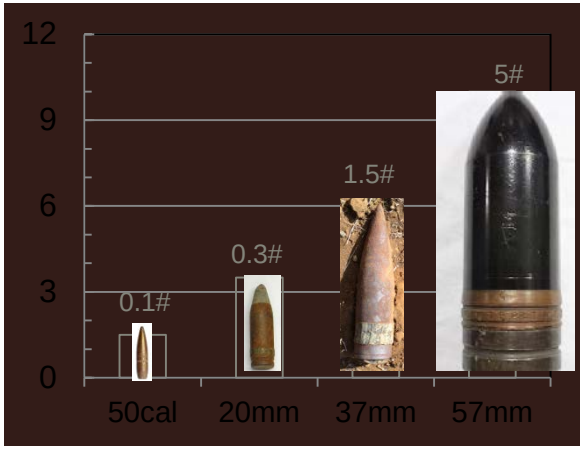
- Leave it in the ground – No 100% ground truth
- Start-to-finish demonstration of complete MEC removal project
  - Contracting, QAPP implementation
  - USACE & State QA Oversight

Technology

- EM61-MKII & MetalMapper detection surveys
- MetalMapper dynamic classification survey
- MetalMapper cued classification survey

Objective

- Safe for future recreation use and development next to new major reservoir







LESSONS LEARNED
LOWRY CLASSIFICATION DEMONSTRATION

Communication, communication, communication

Remedial Design & Planning

- QAPP effective tool as project work plan
- Data quality objectives must be munitions specific
- All QAPP Worksheets are important
- SOPs must be detailed and implementable

Field Implementation

- Don't "Go rogue" – Field teams must follow QAPP & SOPs
- Rigorous QC program – seeding and inspections
- Full root-cause analysis (5 Why's)



KEYS TO REGULATORY ACCEPTANCE
REMEDIAL DESIGN

Begin at the beginning, before contracting
- Agreement on fundamental design and use of classification

Establish clear RAOs for each munitions item
- Identify all munitions of concern and depths
- Must be able to detect before you can classify

Establish verification and validation requirements
- IVS, QA seeds, Library Items, Verification Digs

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KEYS TO REGULATORY ACCEPTANCE
CLASSIFIER DECISION POINTS

No “Black Box” analysis or decisions

Transparent decisions - Detection & Classification
- Understand all decision points
- Well documented decision trees
- Establish decision thresholds, criteria, and standards

Verification and Validation Strategy
- Specifications for data quality and monitoring
- Classifier models and decision thresholds
- Final project results

“Make the right decisions, for the right reasons.” Aristotle

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KEYS TO IMPLEMENTATION
QUALITY ASSURANCE OVERSIGHT

- Demand rigorous remedial design
  - Clearly documented in QAPP
  - Detailed and implementable SOPs
- Disciplined field implementation
  - Strict adherence to QAPP and SOPs
  - Not acceptable to “get to the field, then figure it out”
- QA as QA
  - Expect QC program to find and fix issues
  - No excuses at QA level – failing QA is a big deal
  - Root cause analysis and corrective actions (5 Why’s)

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KEYS TO IMPLEMENTATION
STATE OVERSIGHT FOCUS

Remedial design
- Verify approach for detection and classification
- Confirm munitions-of-interest and depths-of-interest
- Ensure QAPP fully documents project

Decision point verification
- Verify data quality objectives are met
- Validate detection & classification decisions

Quality systems implementation
- Verify full implementation of QAPP and QC/QA
- Independent QA and validation
- Rigorous root-cause analysis and corrective actions

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IMPLEMENTATION CHALLENGES
STATE OVERSIGHT

- Project Manager training
  - Technical fundamentals, design, quality systems and tools
  - Sharing of Lessons Learned and practical experience
- Independent Technical Support
  - Access to independent technical experts
  - Experts to validate design and classifier models
  - Independent data and analysis verification
- Technical Guidance on State Oversight Plans
  - Document available tools and expectations
  - Worksheet companion to QAPP template

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QUESTIONS?



Jordan Adelson
QAPP NINJA

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COMMUNICATING RISK MANAGEMENT

Advanced Geophysical Classification (AGC)

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AGENDA

Basic QAPP

Assessing End States

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WHY BASIC QAPP?

WHEN ACCEPTING DATA & CLOSING OUT PROJECT

Critical Worksheets according to Andy

- WS10: Conceptual Site Model
- WS11: Data Quality Objectives
- WS12: Measurement Performance Criteria
- WS22: Measurement Quality Objectives

Because the QAPP is our best guarantee we're using the right data for all our decisions

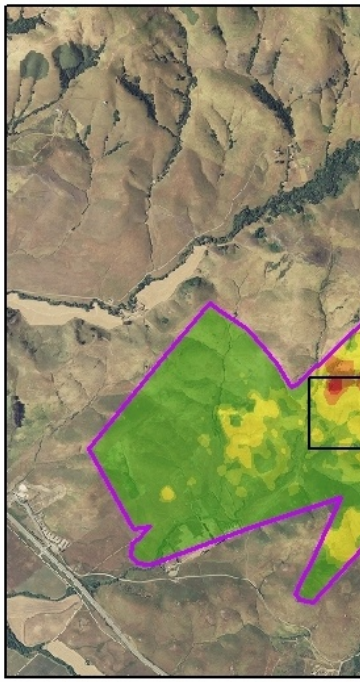
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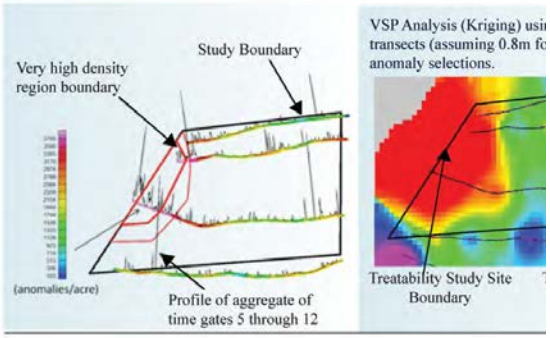
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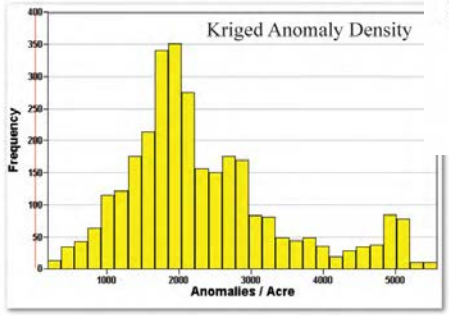
WHEN ACCEPTING DATA & CLOSING OUT PROJECT

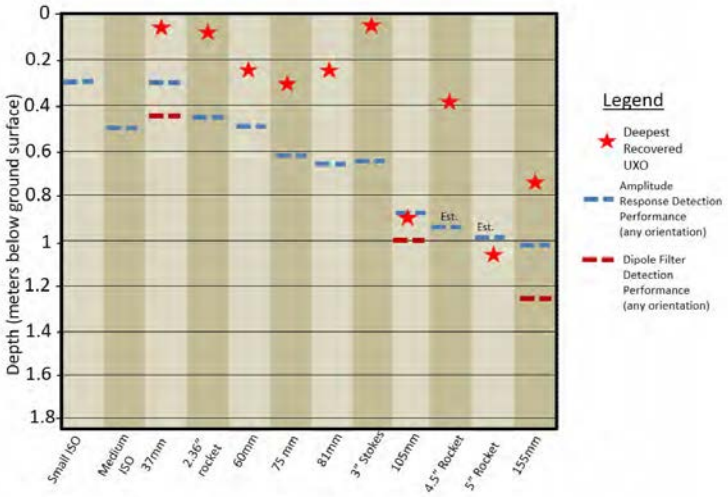
WS10: Conceptual Site Model

- Foundation of entire project
- Explains why we planned what we planned









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BASIC QAPP
WHEN ACCEPTING DATA & CLOSING OUT PROJECT

WS11: Data Quality Objectives

- *GCMR QAPP template is comprehensive*
  - Only needs minor editing for project specific thresholds
  - Explains solutions to relatively simple problem:

    Which anomalies are TOI, which are not

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WS 11 FROM THE TEMPLATE

Step 1: State the Problem. Define the problem that necessitates the study. Examine budget and schedule issues.

Site-specific problem statement: (Example) Previous investigations (list) have indicated that MEC in the form of DMM and UXO including (x, y, and z) are present at site _____, resulting from its use between (years) _____and_____ as a (describe the type of facility and its uses). As shown in the CSM these materials present an unacceptable risk from explosive hazards to (describe current receptors and potential future receptors based on anticipated land use.)

Advanced geophysical classification uses advanced sensors and geophysical classifiers to estimate physical properties of the item (e.g., depth, size, aspect ratio, wall thickness, symmetry) and determine whether the item is a TOI (i.e., highly likely to be MEC) or non-TOI (i.e., highly unlikely to be MEC). Using this information in a structured decision-making process, project teams will be able to make informed decisions about whether an item should be excavated or can be left in place.

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BASIC QAPP
WHEN ACCEPTING DATA & CLOSING OUT PROJECT

WS12: Measurement Performance Criteria

- The single most important Worksheet
  - Because if we meet all these requirements, we're DONE!
  - GCMR QAPP template is comprehensive
    - Edits usually not needed

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BASIC QAPP
WHEN ACCEPTING DATA & CLOSING OUT PROJECT

WS22: Measurement Quality Objectives

- Second most important worksheet
- Tells us the data we're using is good
- GCMR QAPP template is comprehensive
  - Minor edits only for project specific needs

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ASSESSING END STATES

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AGENDA

First Up: Need to make you smart on what you're starting out with

Then: Dive in to implementing and defending our exit plan

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CONTEXT

How We Got Here...

RI→FS→PP/DD→RD→RA QAPP followed by field work

RI→Baseline Risk→Have An Unacceptable Risk Scenario

This means, Per 40 CFR Part 300.430(e)(i), the Lead Agency established remedial action objectives (RAOs) that *specify:*

- ***contaminants and media of concern***
- ***potential exposure pathways****, and*
- ***remediation goals***”

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GENERAL RESPONSE ACTIONS

The Three General Response Actions in our GRA Toolbox

~~No Action~~
(Not an action)

Modify Behavior

Restrict / Preclude Access

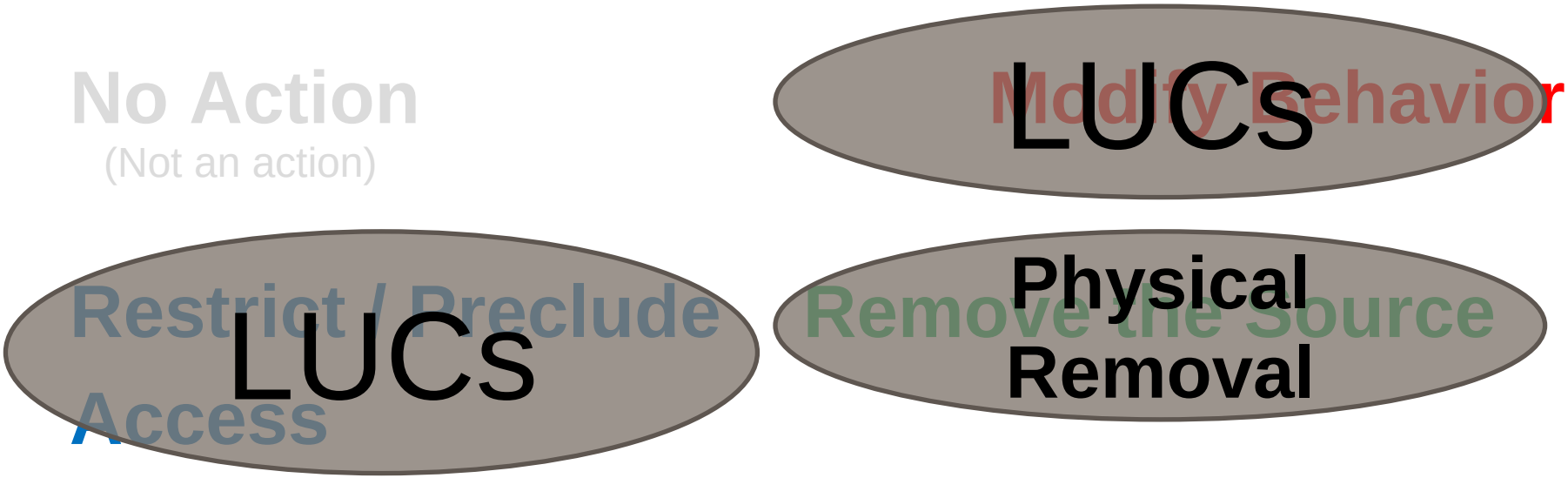
Remove the Source

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GENERAL RESPONSE ACTIONS

The four General Response Actions in our GRA Toolbox



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RAO IN PLAIN ENGLISH

HTRW: “Meet this standard” (i.e. 30ppm Pb in soil)

MMRP: When we can show either:

1. People aren’t likely to encounter UXO, or
2. People know what NOT to do if they encounter a UXO,
3. The consequences are not severe, or
4. A combination of the above

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RISK CALCULATIONS

Andy's Auto Insurance Who's ahead, Andy or his insurance company?	
Event	**Value**
Sound System theft 2010	$1,500
Sound System theft 2012	$1,000
Crazed Soccer Mom driving a minivan talking on the phone	$6,700
Total Claims Payouts	$9,200
My approximate lifetime premiums paid to date	~$350/6mo for 12 years = $8,400

- Risk is essentially a combination of probabilities
- Example: Your Car Insurance Rate
  - probability of having an accident
    - Hours on the road, your experience, your driving history
  - probability you will make a claim



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WE ARE TALKING PROBABILITIES

What's the probability of rolling a 6?

One in six, or about 16%



What's the probability of rolling two sixes?

one in six? (~16%)

two in twelve? (~16%)

one in six + one in six? (~32%)

one in six X one in six? (~3%)



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RISK CALCULATIONS

Risk is essentially the multiplication of several probabilities

Example: Lead In Soil

- probability of exposure
  (being present where the contamination is)
- probability of intake
  (something happens that results in ingestion)
- probability of bioloading
  (probability your body retains the contaminant)
- probability of adverse health effect
  (probability that the retention ultimately leads to a health effect)

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SOMETHING BAD HAPPENS WHEN:

- ✓ UXO or DMM is at a location
- ✓ Someone imparts energy to the item
- ✓ The item functions
- ✓ Energy from the detonation injures that someone

Consider Reality:

UXO are generally rare

Just because it's there does not mean someone finds it

If it is found, it's not always picked-up

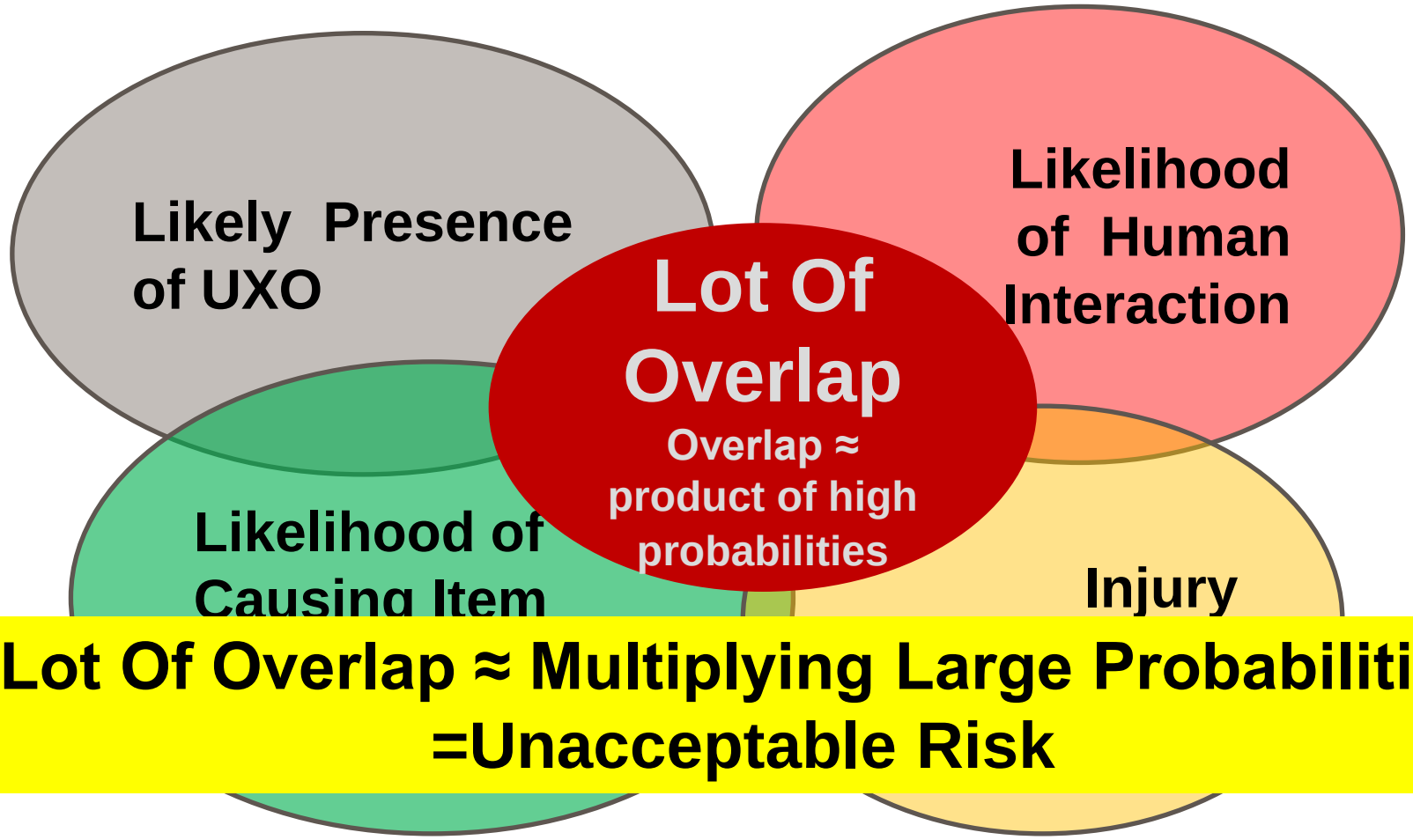
If it is picked up, it doesn't automatically detonate

If it does detonate, injury is proportional to energy release

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RISK MANAGEMENT

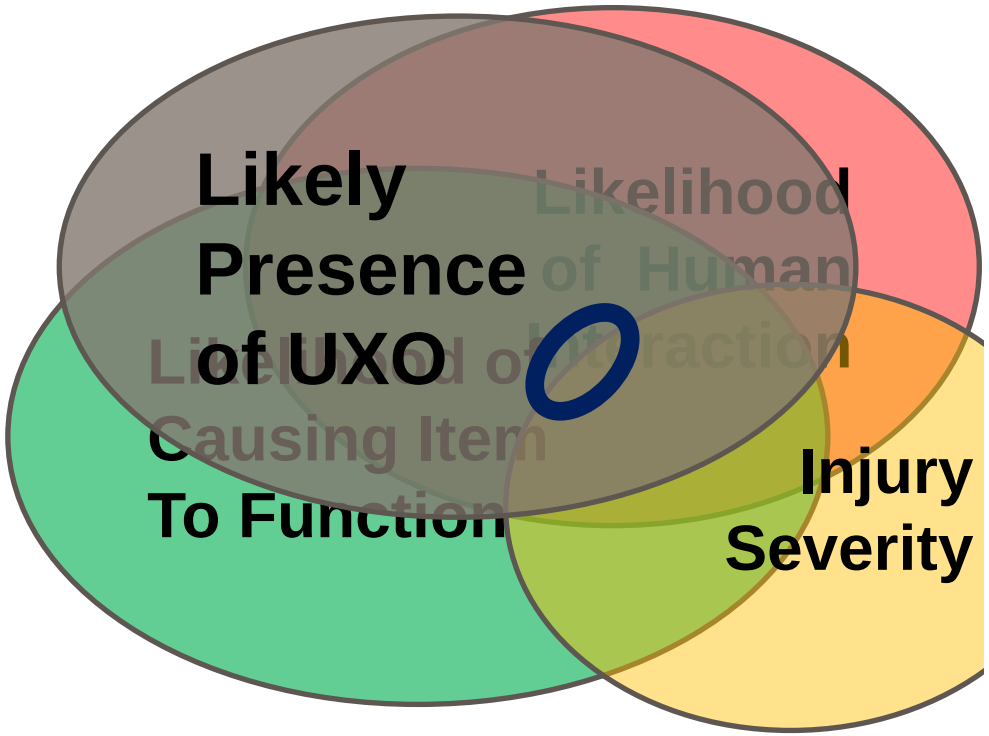


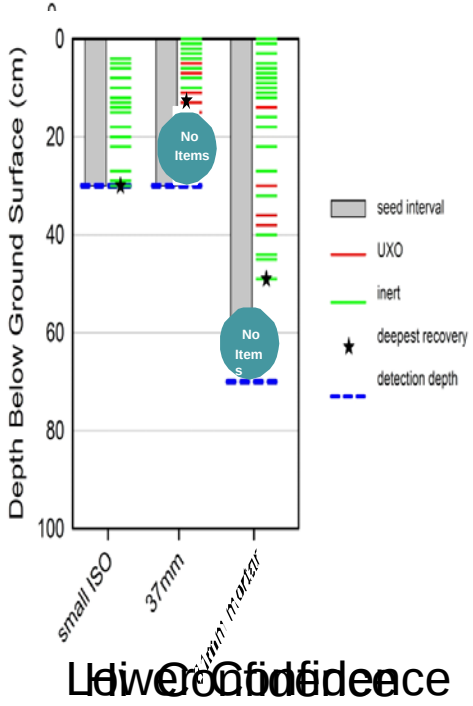
Lot Of Overlap ≈ Multiplying Large Probabilities =Unacceptable Risk

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LET'S LOOK AT: PHYSICAL REMOVAL



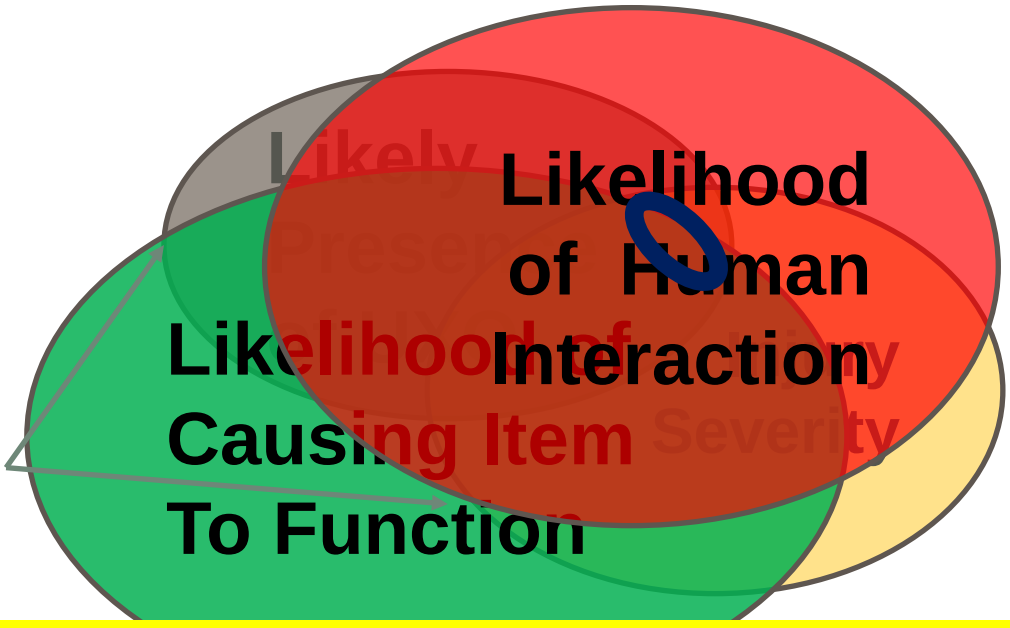


Little To No Overlap ≈ Multiplying small probabilities = Acceptable End State

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LET'S LOOK AT: EDUCATION



These stay the same!

Little To No Overlap ≈ Multiplying small probabilities = Acceptable End State

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EXAMPLE

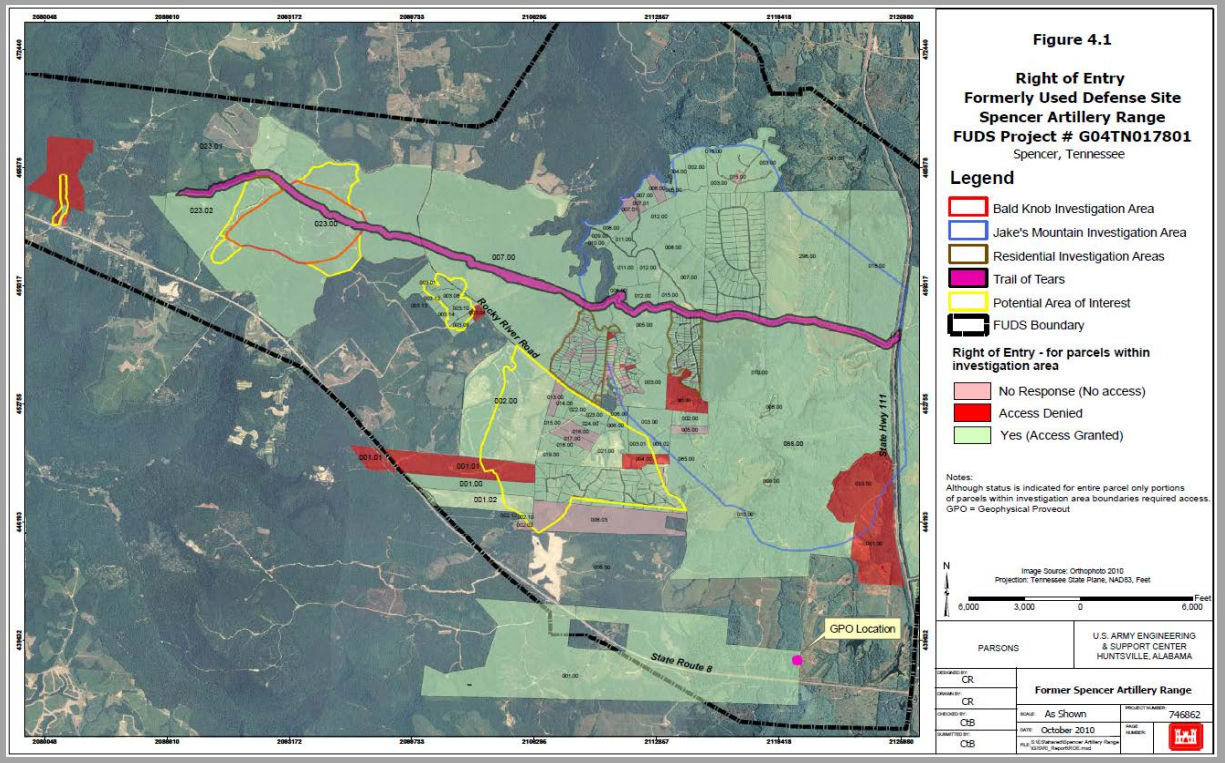
- Potential Acceptable End-States
  - CSM:

Documented Use As Target Areas

Confirmed Use as HE Training

Interaction expected during land use

Current and planned land use:
1- Residential
2- Agricultural



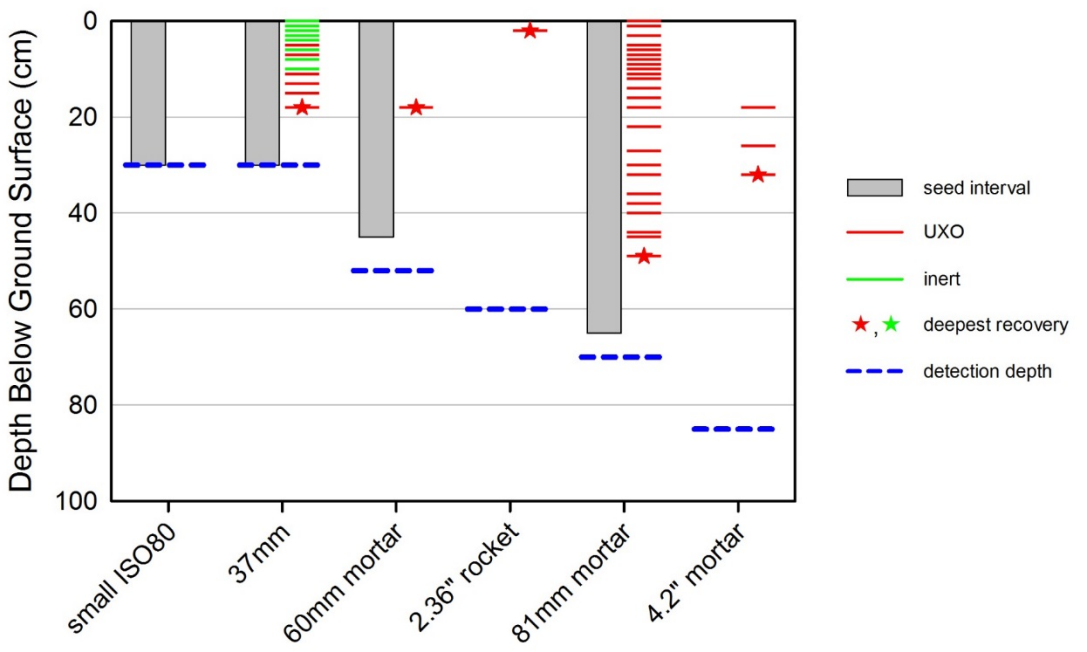
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EXAMPLE

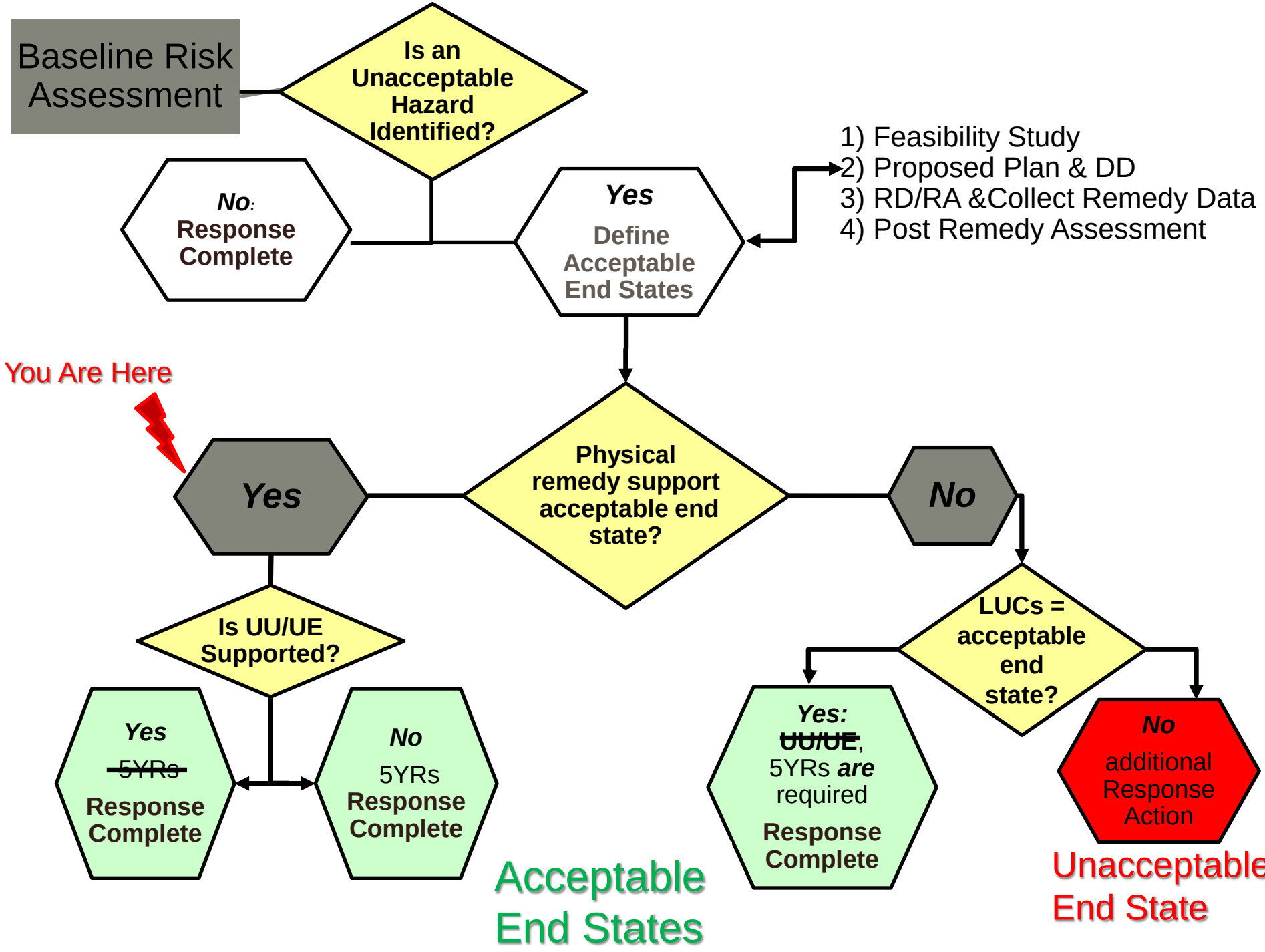
- Potential Acceptable End-States

  - 100% coverage & High Confidence UXO recovery →Unlikely Encounter
    - Potential for UU/UE
    - 5-year reviews if no UU/UE
    - Are LUCs or ICs needed?
    - Al



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Baseline Risk Assessment
Is an Unacceptable Hazard Identified?
No: Response Complete
Yes
Define Acceptable End States
1) Feasibility Study
2) Proposed Plan & DD
3) RD/RA &Collect Remedy Data
4) Post Remedy Assessment
You Are Here
Physical remedy support acceptable end state?
Yes
No
Is UU/UE Supported?
Yes
~~5YRs~~
Response Complete
No
5YRs
Response Complete
LUCs = acceptable end state?
Yes:
~~UU/UE~~,
5YRs are required
Response Complete
No
additional Response Action
Acceptable End States
Unacceptable End State

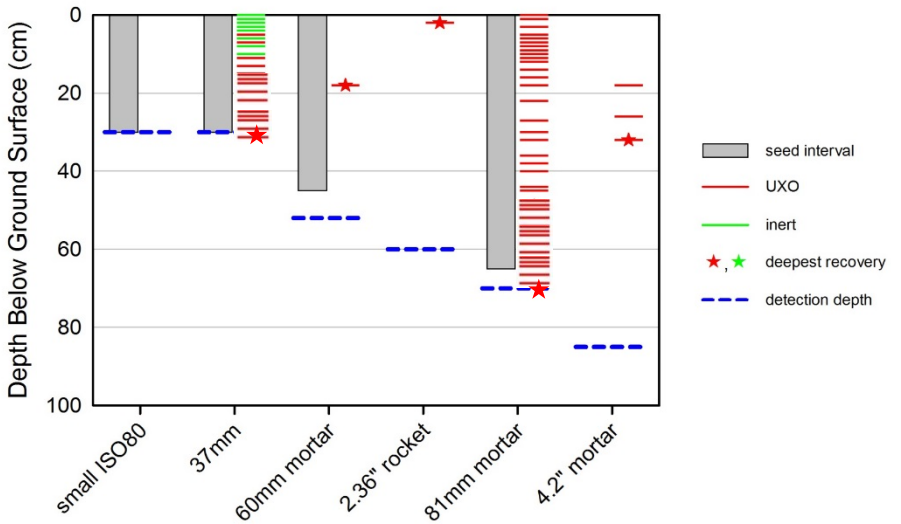
EXAMPLE

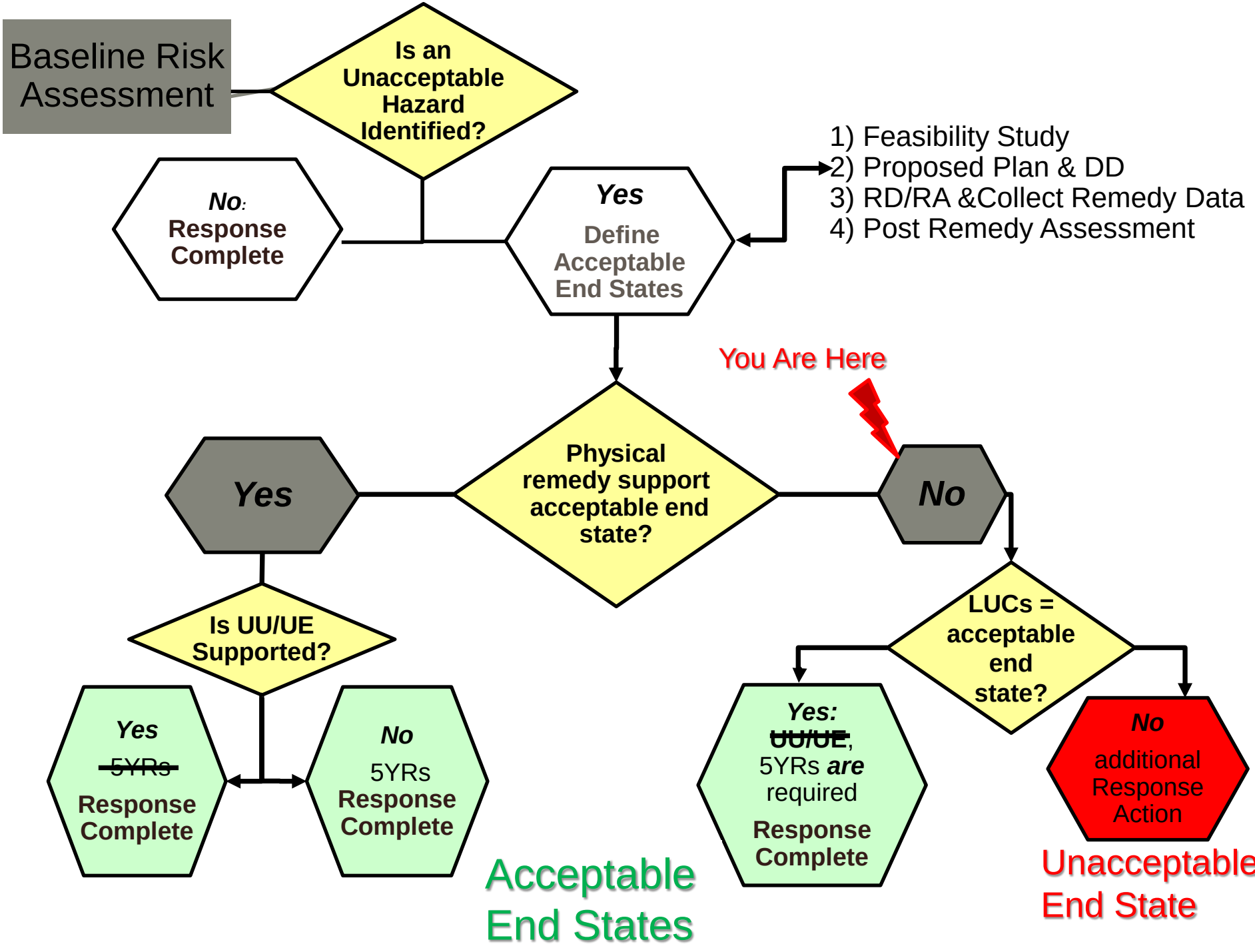
- Potential Acceptable End-States

➢ 100% coverage & High Confidence UXO recovery →Unlikely Encounter
  - ➢ Potential for UU/UE
  - ➢ 5-year reviews if no UU/UE
  - ➢ Are LUCs or ICs needed?

➢ **No.** LUCs or ICs don't provide any added benefit → Already at Unlikely Encounter

➢ 100% coverage, Moderate Confidence UXO recovery→Seldom
  - ➢ Are LUCs or ICs needed?




Baseline Risk Assessment
Is an Unacceptable Hazard Identified?
No: Response Complete
Yes
Define Acceptable End States
1) Feasibility Study
2) Proposed Plan & DD
3) RD/RA &Collect Remedy Data
4) Post Remedy Assessment
You Are Here
Physical remedy support acceptable end state?
Yes
No
Is UU/UE Supported?
Yes
~~5YRs~~
Response Complete
No
5YRs
Response Complete
LUCs = acceptable end state?
Yes:
~~UU/UE~~,
5YRs are required
Response Complete
No
additional Response Action
Acceptable End States
Unacceptable End State

EXAMPLE

- Potential Acceptable End-States

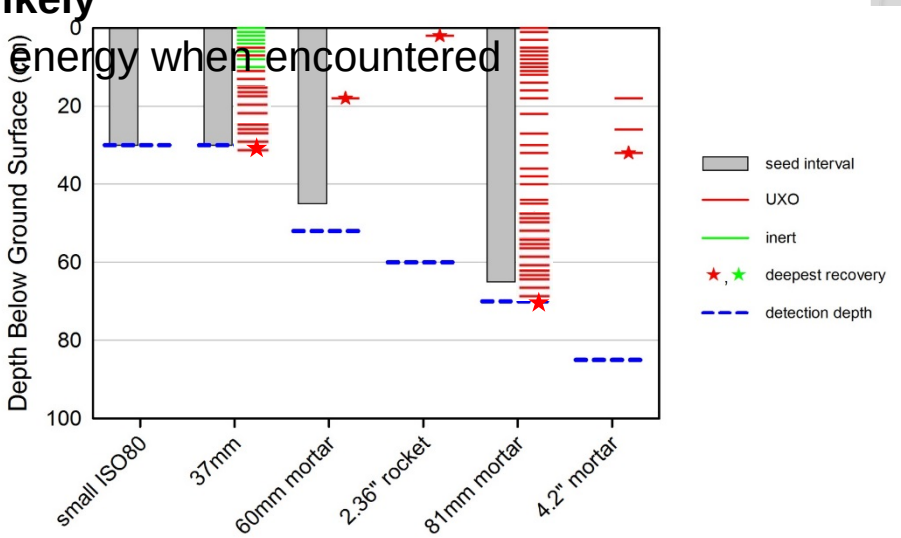
➢ 100% coverage & High Confidence UXO recovery →Unlikely Encounter
  - ➢ Potential for UU/UE
  - ➢ 5-year reviews if no UU/UE
  - ➢ Are LUCs or ICs needed?

➢ **No.** LUCs or ICs don't provide any added benefit → Already at Unlikely Encounter

➢ 100% coverage, Moderate Confidence UXO recovery→Seldom
  - ➢ Are LUCs or ICs needed?

➢ **Yes →Unlikely**

- LUCs/ICs achieve Unlikely to impart energy when encountered
- Program LUCs/ICs costs indefinitely
- 5-year reviews



EXAMPLE

▪ Potential Acceptable End-States (con.t)

- Large contiguous area with 100% (or reduced coverage under infrastructure) coverage and ***No UXO or DMM or other native TOI recovered***
  - Indicates buffer/safety zones between/around targets
  - Potential for UU/UE? ➢**Yes**
  - 5-year reviews if no UU/UE
  - LUCs or ICs? Don't provide any added benefit → already at Unlikely Encounter

- 100% (or reduced coverage under infrastructure) coverage, High confidence intact UXO recovered, moderate confidence small, modest injury potential fuze components recovered
  - High confidence intact UXO recovered → achieves Unlikely Encounter for those items
  - Moderate confidence fuzes recovered → achieves Seldom Encounter for those items
  - LUCs or ICs?

Not likely → Both cases ***Acceptable***

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SUMMARY

We Achieve one or more GRAs through

- Physical Removal
- LUCs
- Combination

Risk is the product of probabilities (in our current formulation)

p(presence) x p(encounter) x p(detonation) x p(injury)

LUCs need to increase effectiveness of the remedy, AND the remedy effectiveness needs the bump!

More than one End State *definition* is likely throughout an MRS

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VISUAL SAMPLE PLAN

Advanced Geophysical Classification (AGC)

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Things you need to know about Visual Sample Plan

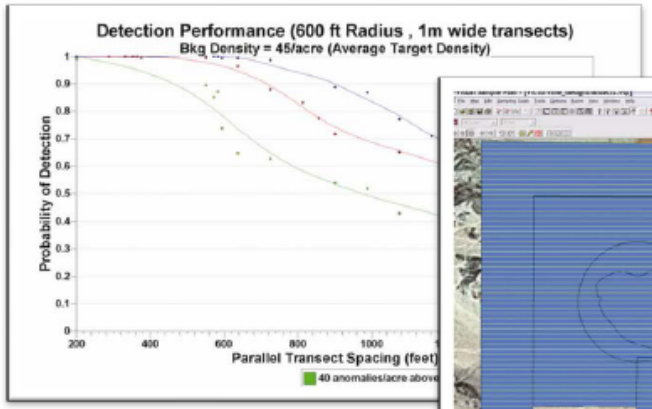
The VSP Sparse Transect Sampling Tools have been completed and demonstrated.

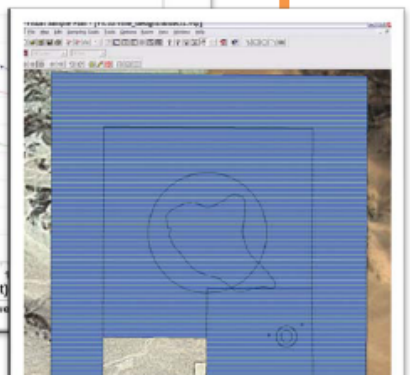
Statistical Transect Design

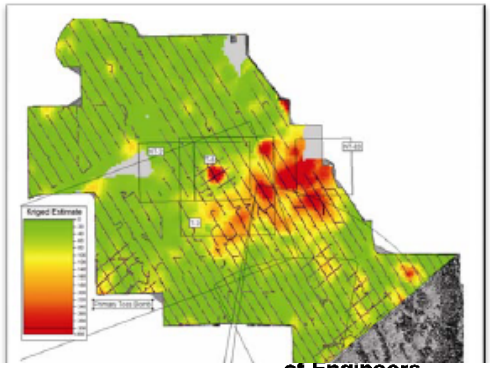
- Quantify the probability of traversing and detecting a target area with a specified transect spacing.

Sparse Transect Analysis

- Sparse transect density analysis tools developed specifically for DoD surveys.
- Geostatistical Modeling and mapping.







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VSP

Purpose *is*: to find area(s) with elevated anomaly densities.
Purpose *is not*: to delineate extent of UXO, or even to find UXO

Design

CSM accuracy is not critical

- VSP will tell you how to find the "area" you define
- Can bias towards conservative assumptions
- Okay if you get it wrong

Can be step-wise process

- Look for larger areas first
- Look for smaller areas if needed

Analysis

Does not incorporate design CSM

Will tell you what you found

Can run multiple scenarios to test various assumptions

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UNDERLYING PRINCIPLE

The “thing” we’re looking for has more anomalies per acre than the area surrounding it

We need at least one transect through that “thing” (sometimes more, VSP’s planning module will tell us)



Pin-flags everywhere

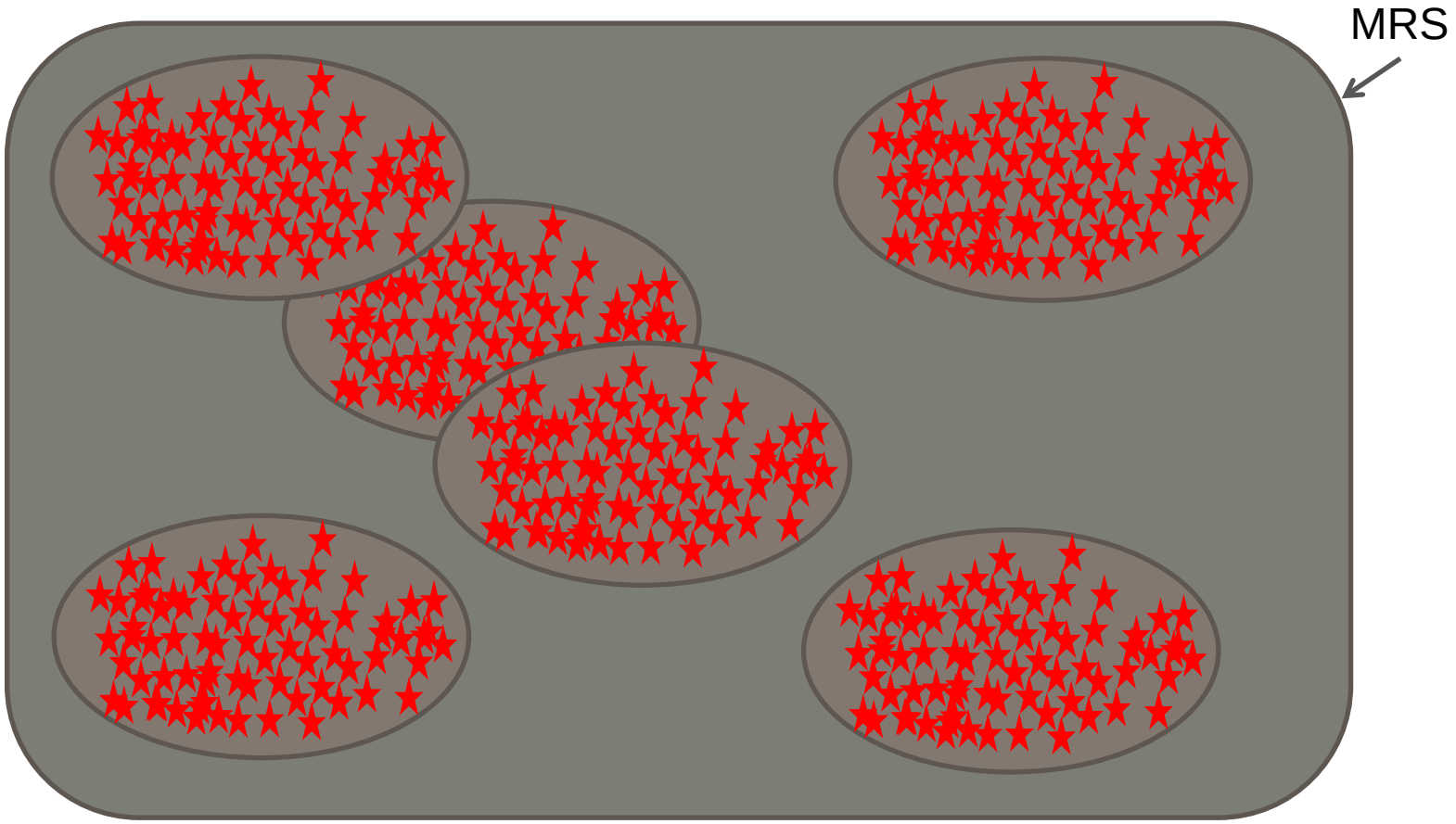


No pin-flags

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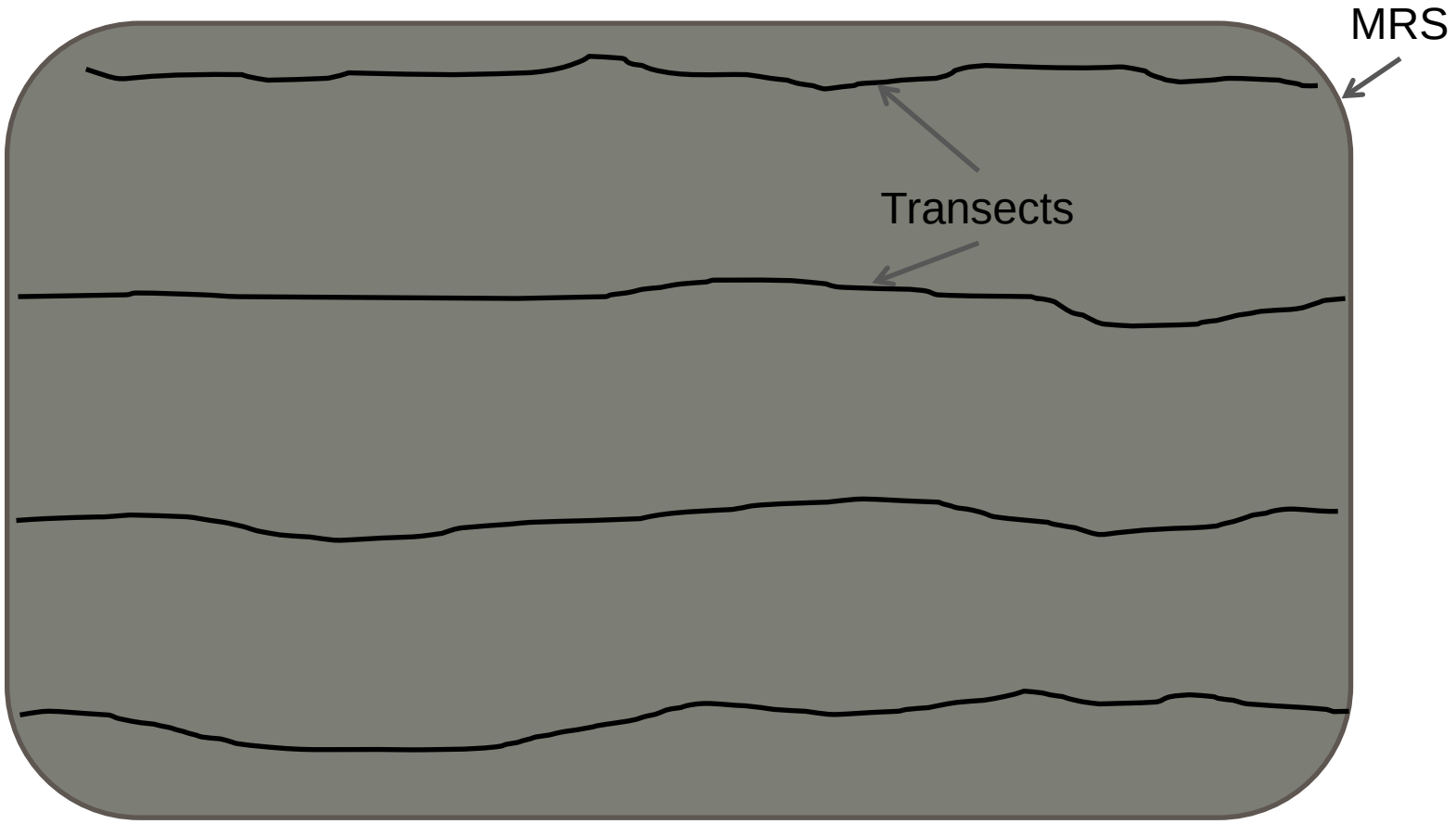
SIMPLIFIED EXAMPLE



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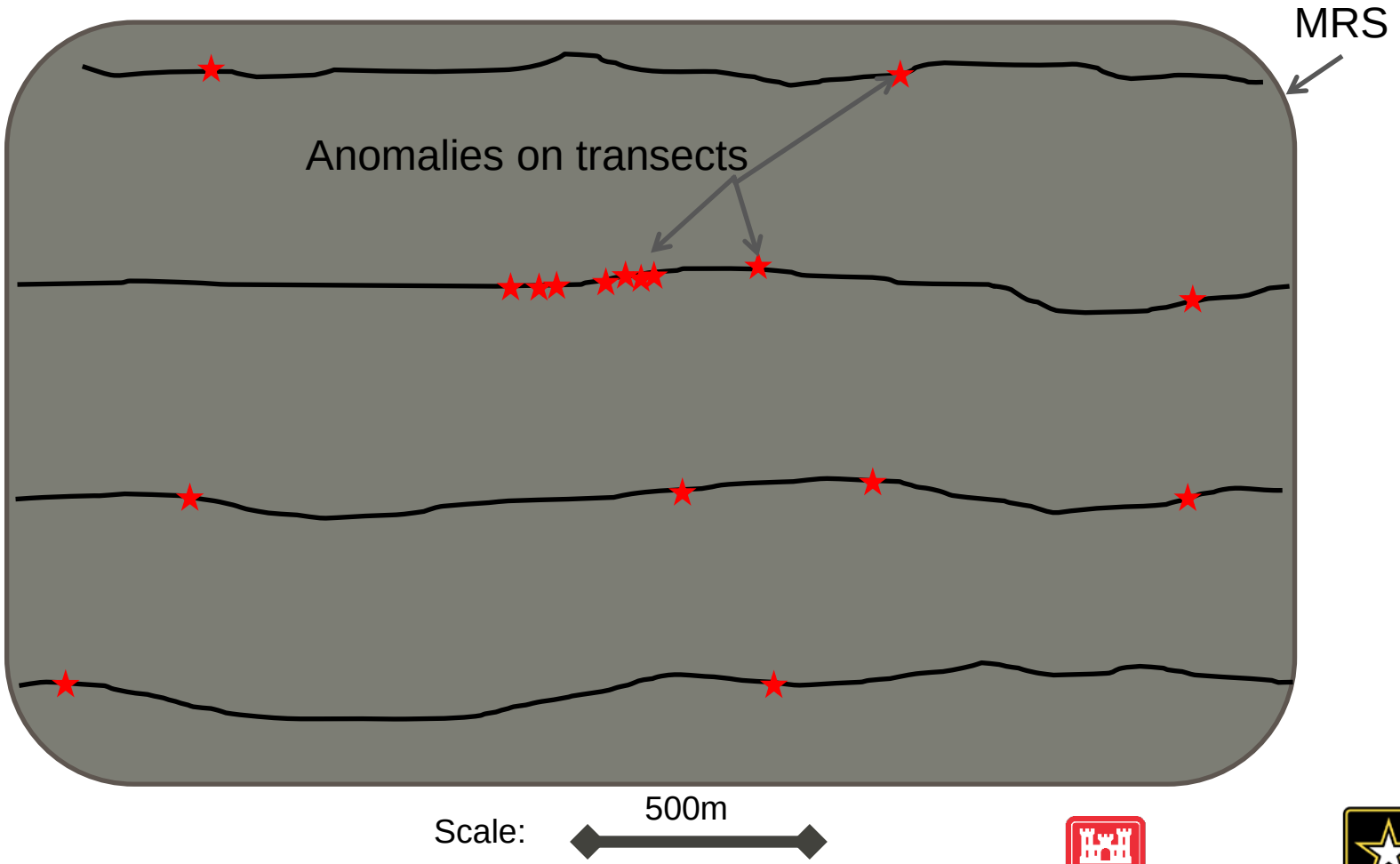
SIMPLIFIED EXAMPLE



US Army Corps of Engineers

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SIMPLIFIED EXAMPLE

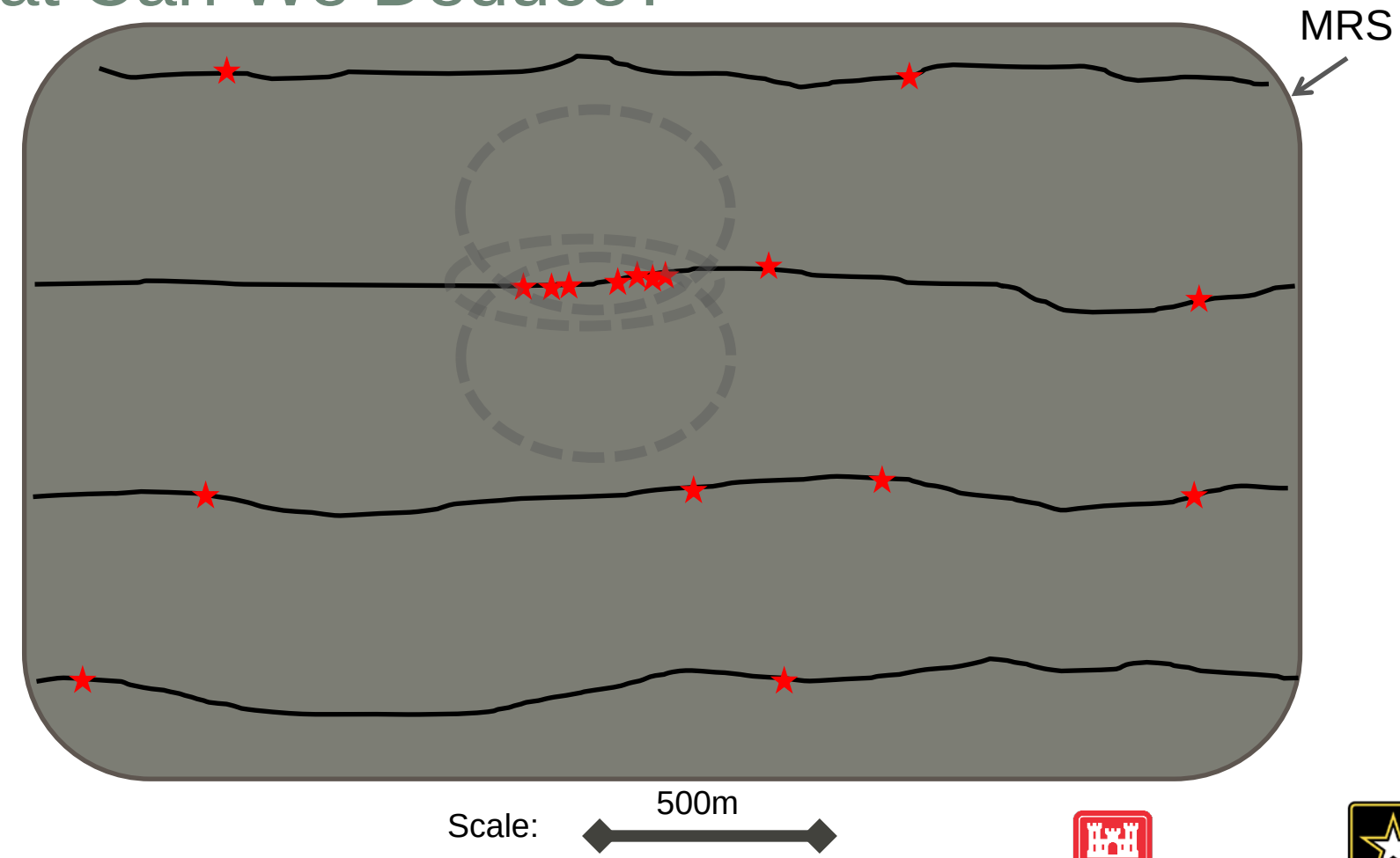


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SIMPLIFIED EXAMPLE

What Can We Deduce?



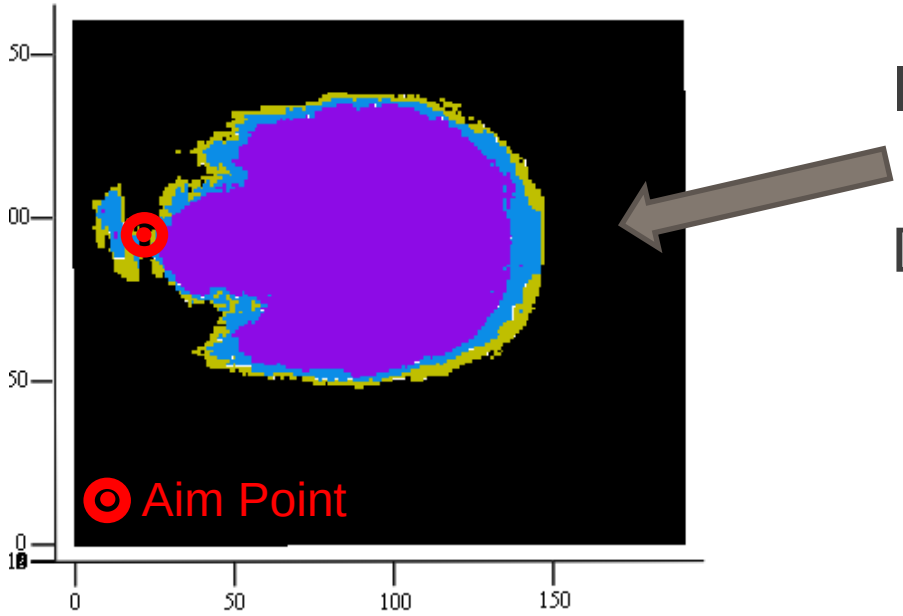
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VSP BASICS

Model:

60mm M49A3 fragmentation distribution
(1500 rounds)



Detection Confidence
Purple >25 anomalies/acre
Blue >15 anomalies/acre
Yellow >5 anomalies/acre

- Initial R&D Problem was to find this
- Design Phase uses Monte Carlo simulations to estimate probabilities of traversing area & detecting anomalies
- Analysis Phase just looks at the data
  - Geostatistics

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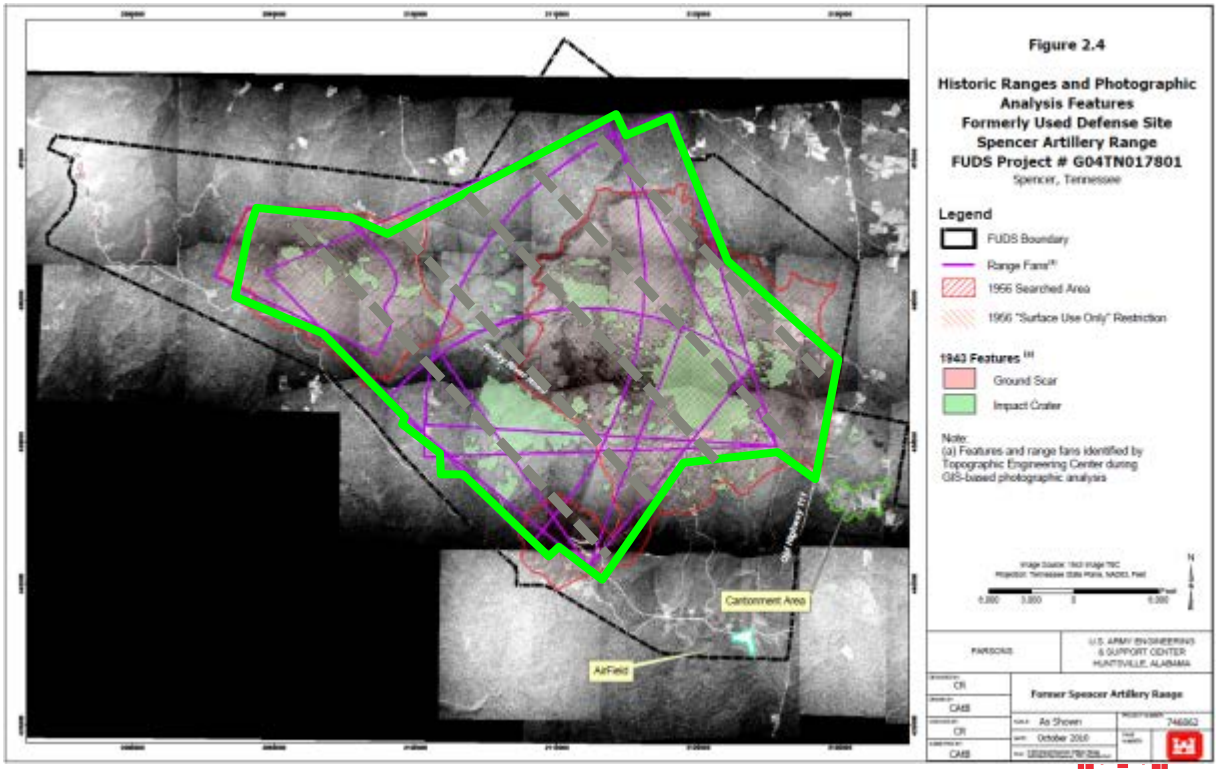
U.S.ARMY

GENERAL CONCEPTS

If: Many munitions types & Heavy use

- Then: Start looking for Largest Area First

Known:
220mm
155mm
105mm
75mm
37mm



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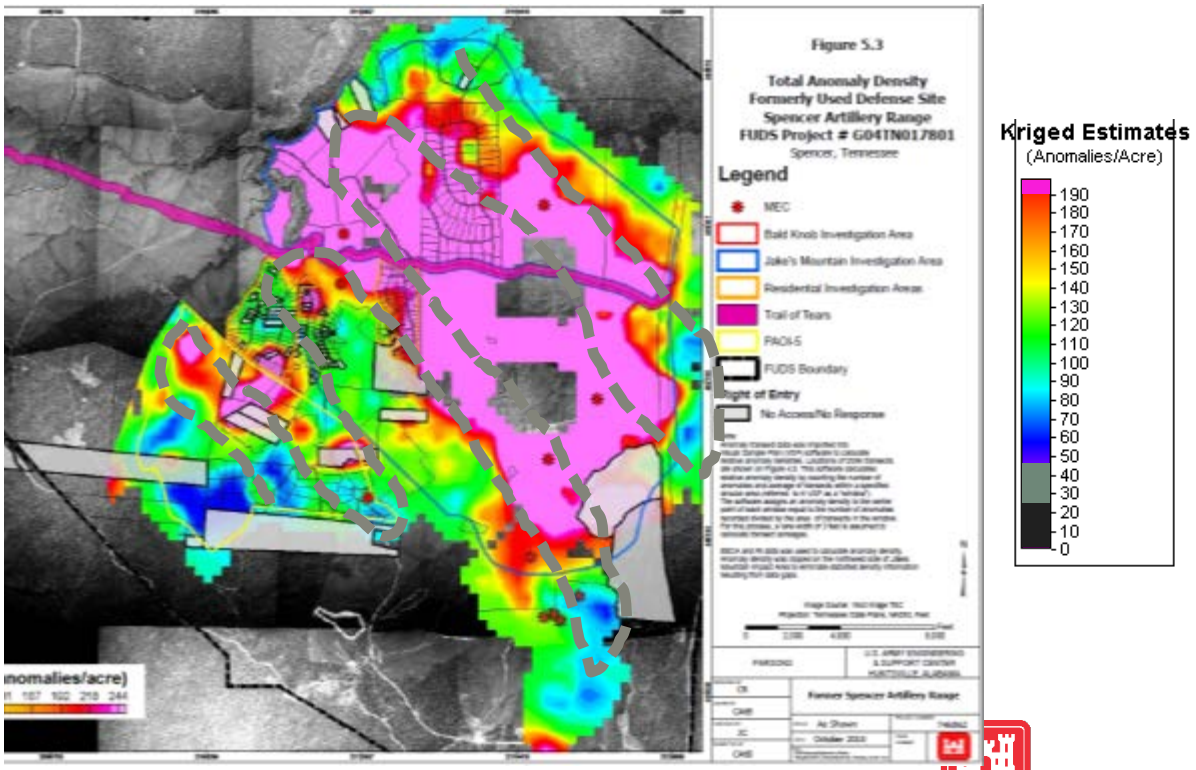
U.S.ARMY

GENERAL CONCEPTS

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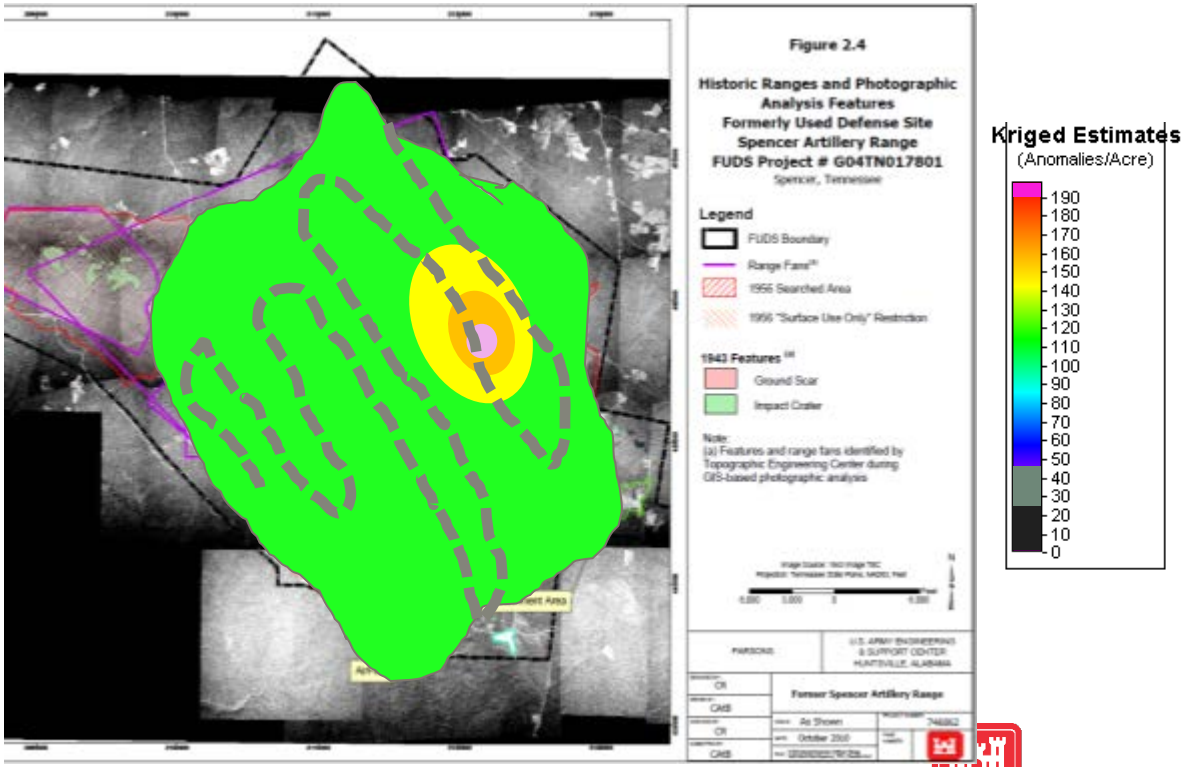
US Army Corps of Engineers

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GENERAL CONCEPTS

If: Don't find what you expected

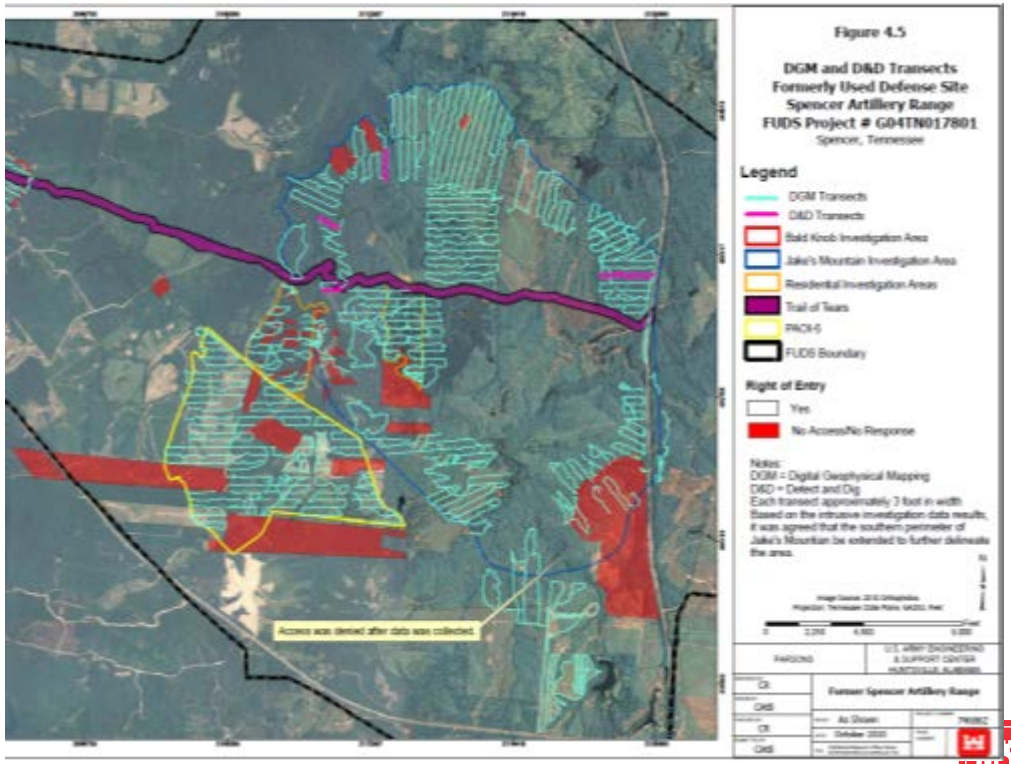
- Then: Do more



GENERAL CONCEPTS

If: Don't find what you expected

- Then: Do more



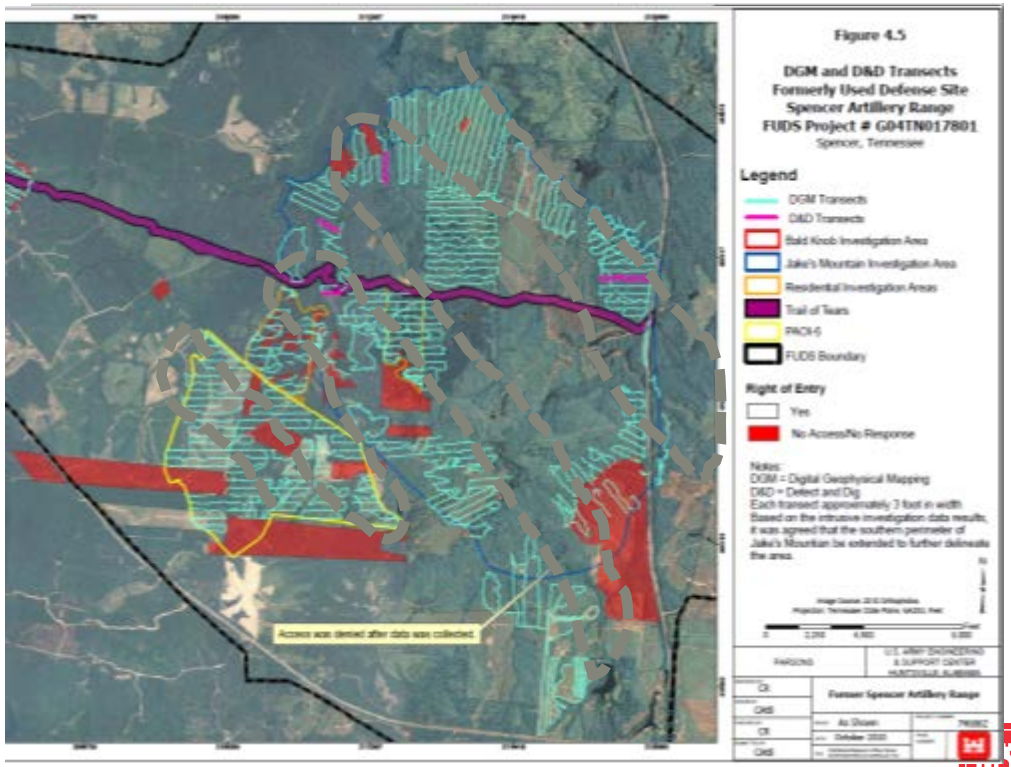
US Army Corps of Engineers

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GENERAL CONCEPTS

If: Don't find what you expected

- Then: Do more



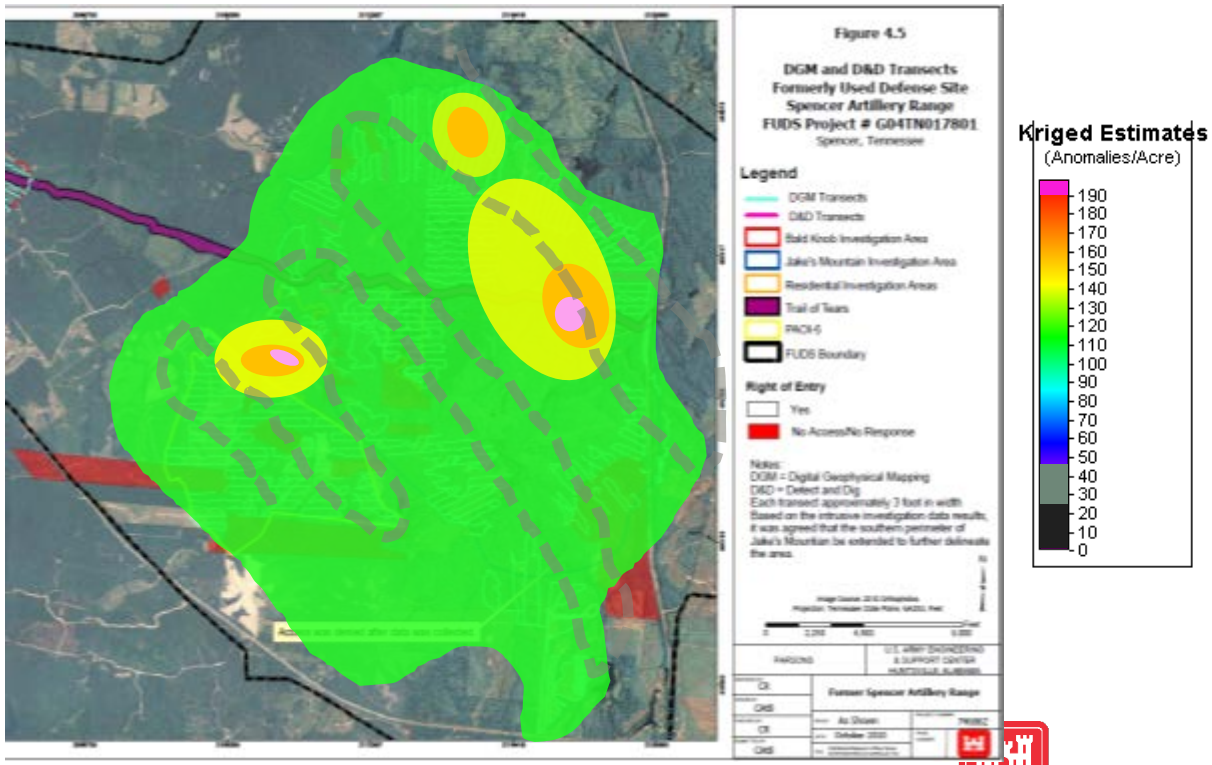
US Army Corps of Engineers

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GENERAL CONCEPTS

If: Don't find what you expected

- Then: Do more



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YOU GET TO DEFINE “TARGET AREA”

Any scenario where there is a contrast between “background” anomaly densities and densities in the “area” you are trying to find

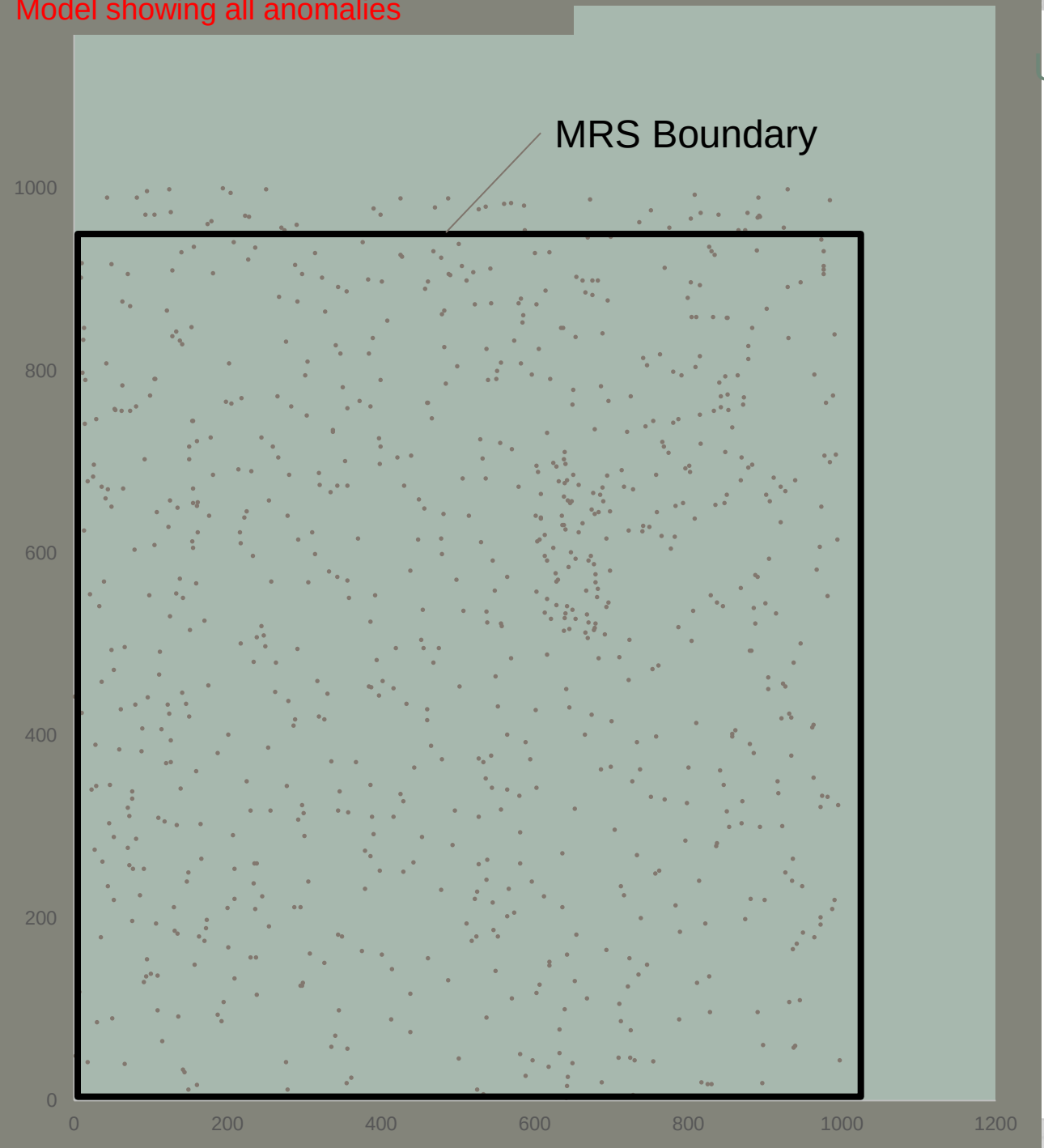
- Typical practice target (normal distribution)
- Open Detonation area (normal distribution)
- Maneuver area (uniform distribution model)
- Could even be a disposal pit (but the geophysical detection definition will be different)

} Original R&D Problem

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Model showing all anomalies



Example: Contrast Uniform Distribution

250 ACRE MRS

SUSPECTED 5AC MANEUVER AREA

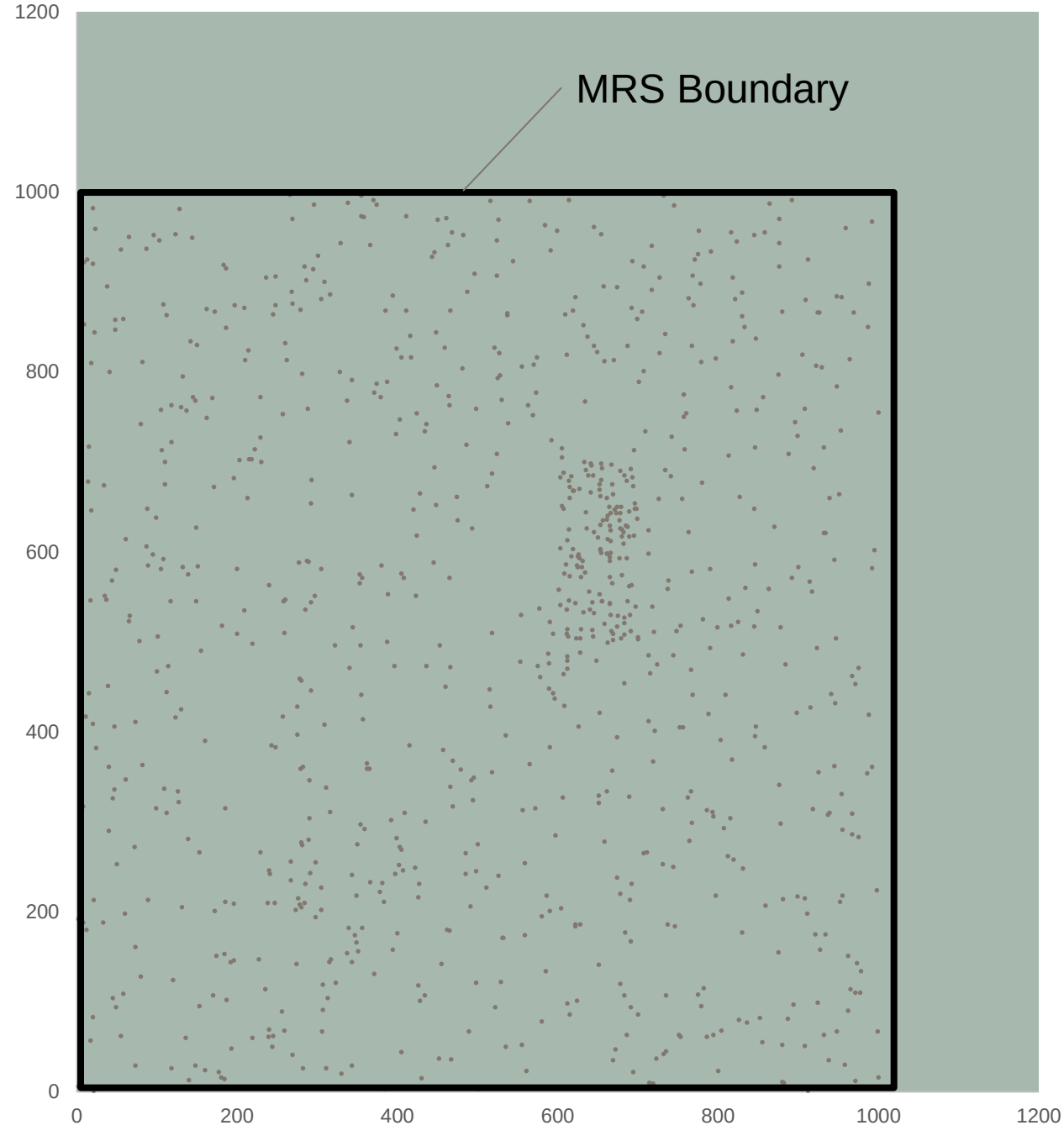
BACKGROUND ANOMALY DENSITY: 10 BKG/ACRE (UNIFORM DISTRIBUTION)

MANEUVER AREA DENSITY: 10 /ACRE (UNIFORM DISTRIBUTION)

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Model showing all anomalies



Example: Contrast Uniform Distribution

250 ACRE MRS

SUSPECTED 5AC MANEUVER AREA

BACKGROUND ANOMALY DENSITY: 10 BKG/ACRE (UNIFORM DISTRIBUTION)

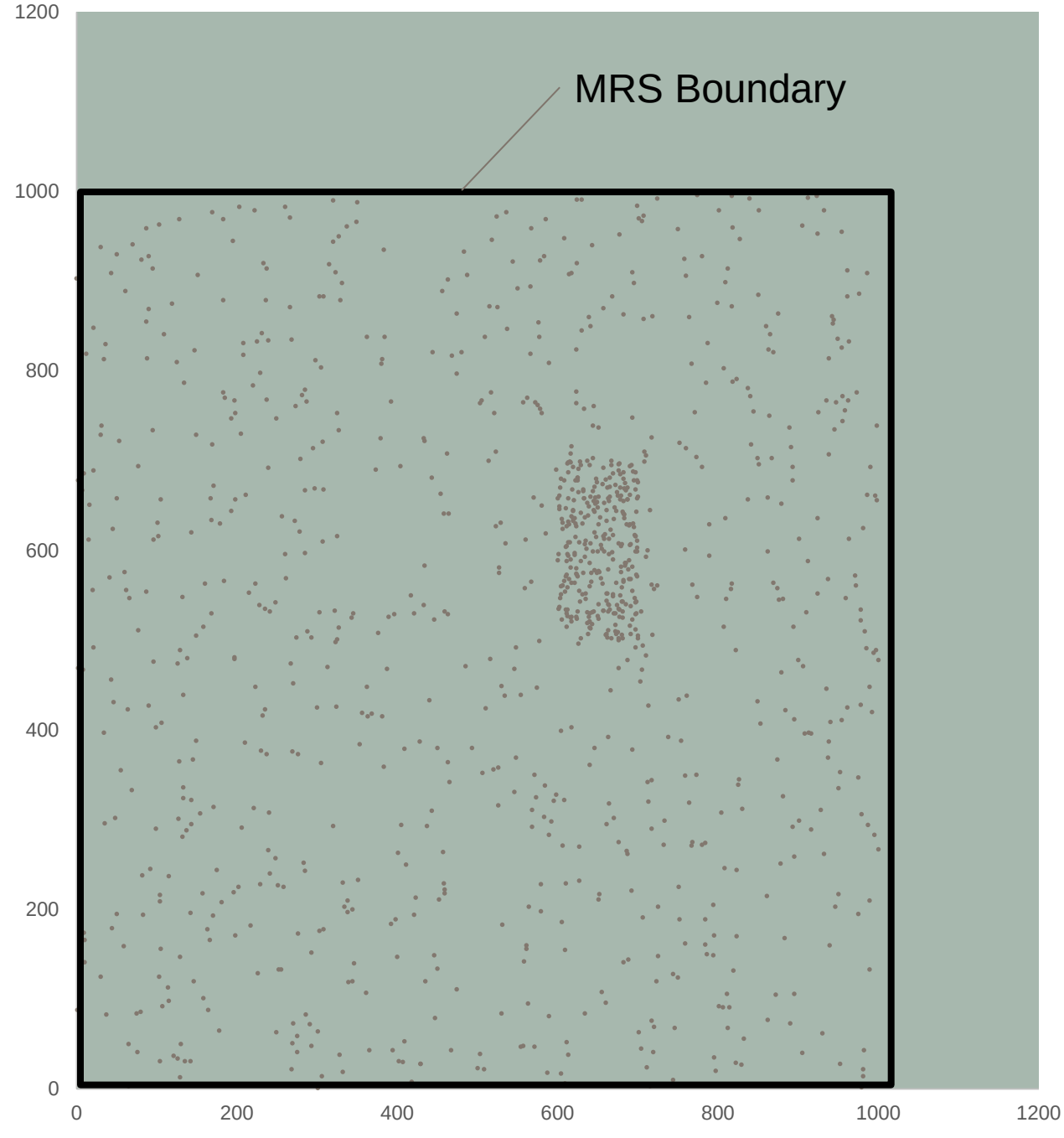
MANEUVER AREA DENSITY: 20 /ACRE (UNIFORM DISTRIBUTION)

Where is the area?

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Model showing all anomalies



Example: Contrast Uniform Distribution

250 ACRE MRS

SUSPECTED 5AC MANEUVER AREA

BACKGROUND ANOMALY DENSITY:
10 BKG/ACRE
(UNIFORM DISTRIBUTION)

MANEUVER AREA DENSITY:
50 /ACRE
(UNIFORM DISTRIBUTION)

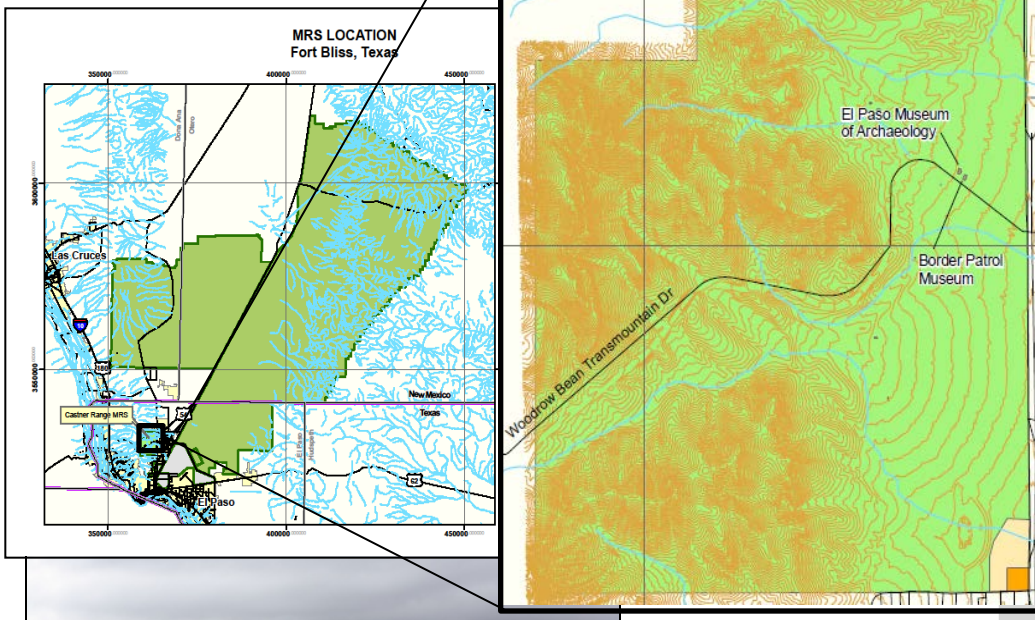
Where is the area?

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CASE STUDY
CASTNER RANGE, FT BLISS

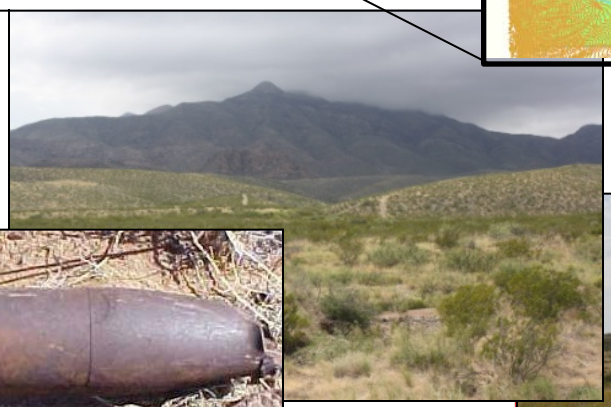
- Size (7,000 acres)
- Three Factors to define target shape
  - Where rounds land
  - Where the frag goes
  - Firing directions











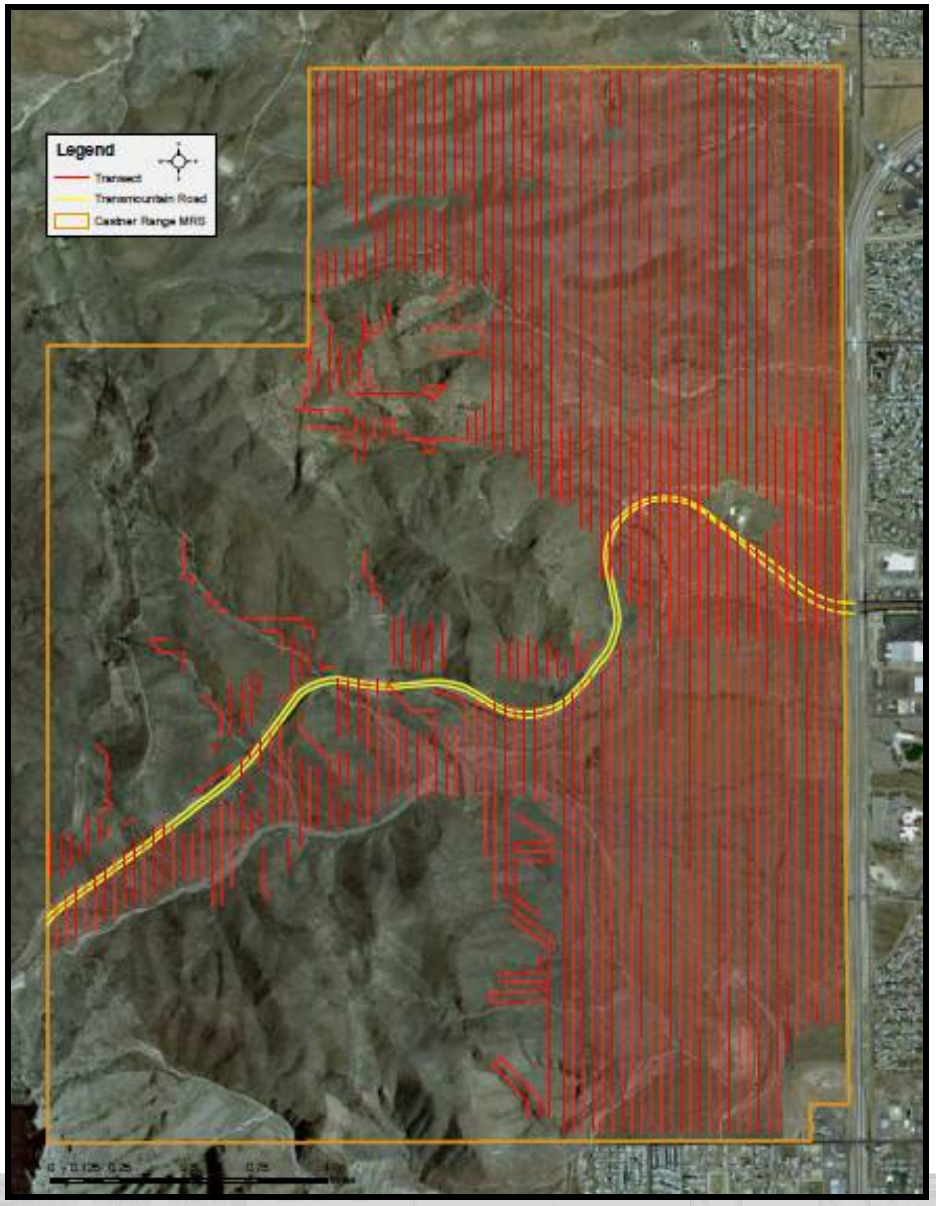


VSP EXERCISE

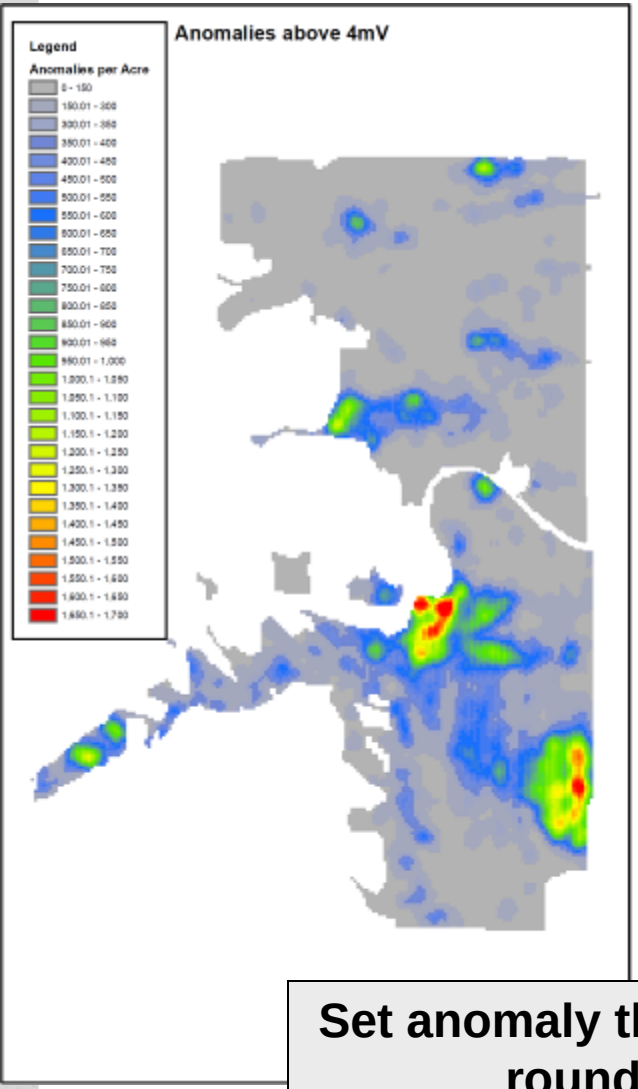
Assumed Munition: 2.36" Rocket
- Semi-major Axis: 6m + 38m = 44
- Semi-minor Axis: 2m + 38m = 40

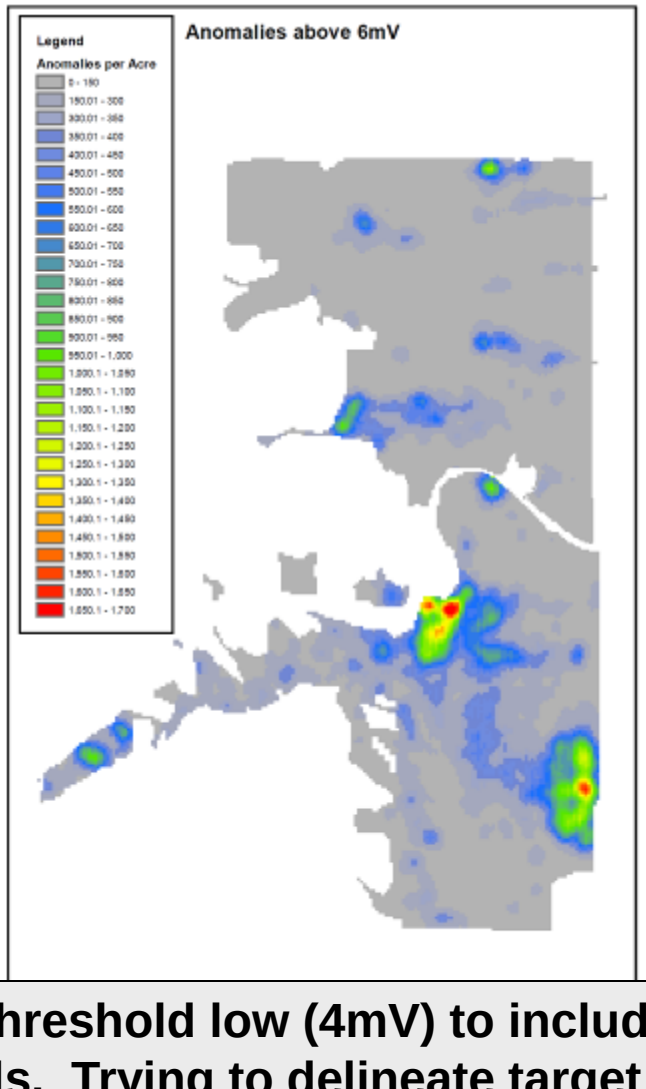
Random Target Orientation

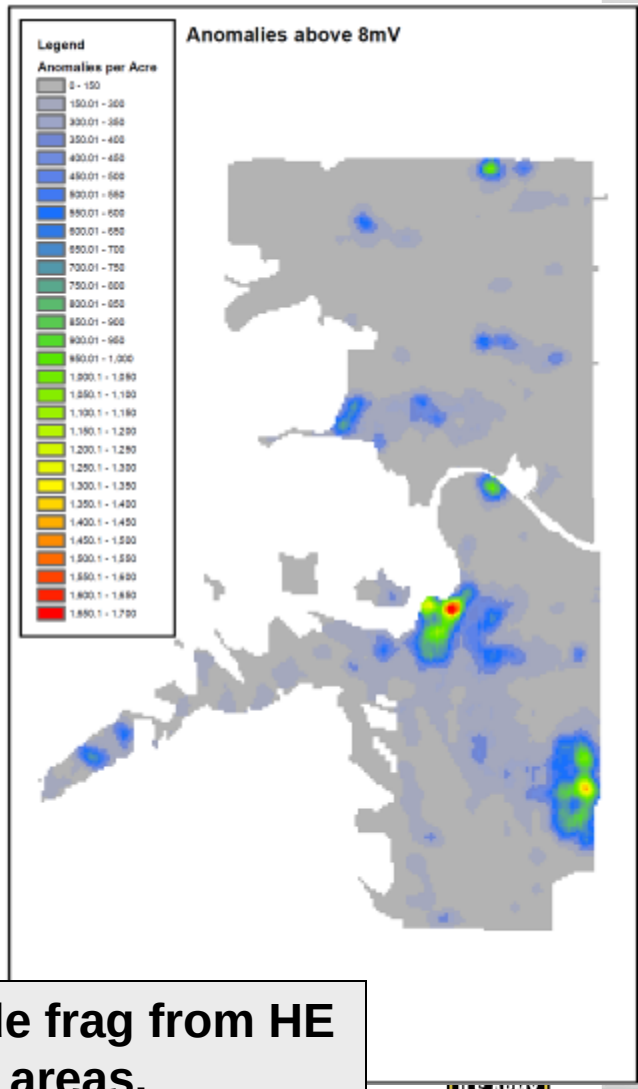
VSP Calculated Transect Spacing = 57m



DGM ANOMALY DENSITIES: VARIABLE MV THRESHOLD

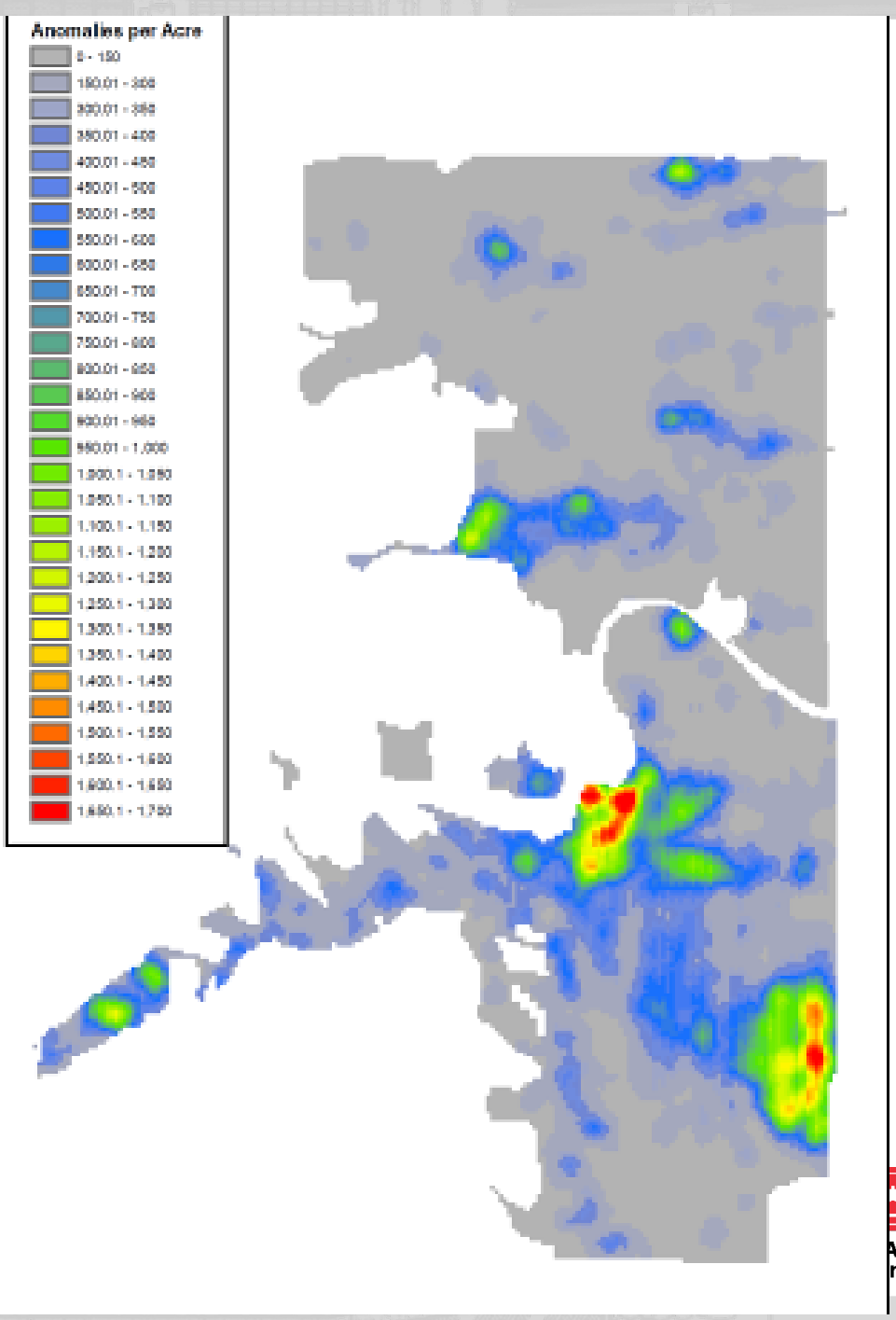






Set anomaly threshold low (4mV) to include frag from HE rounds. Trying to delineate target areas.

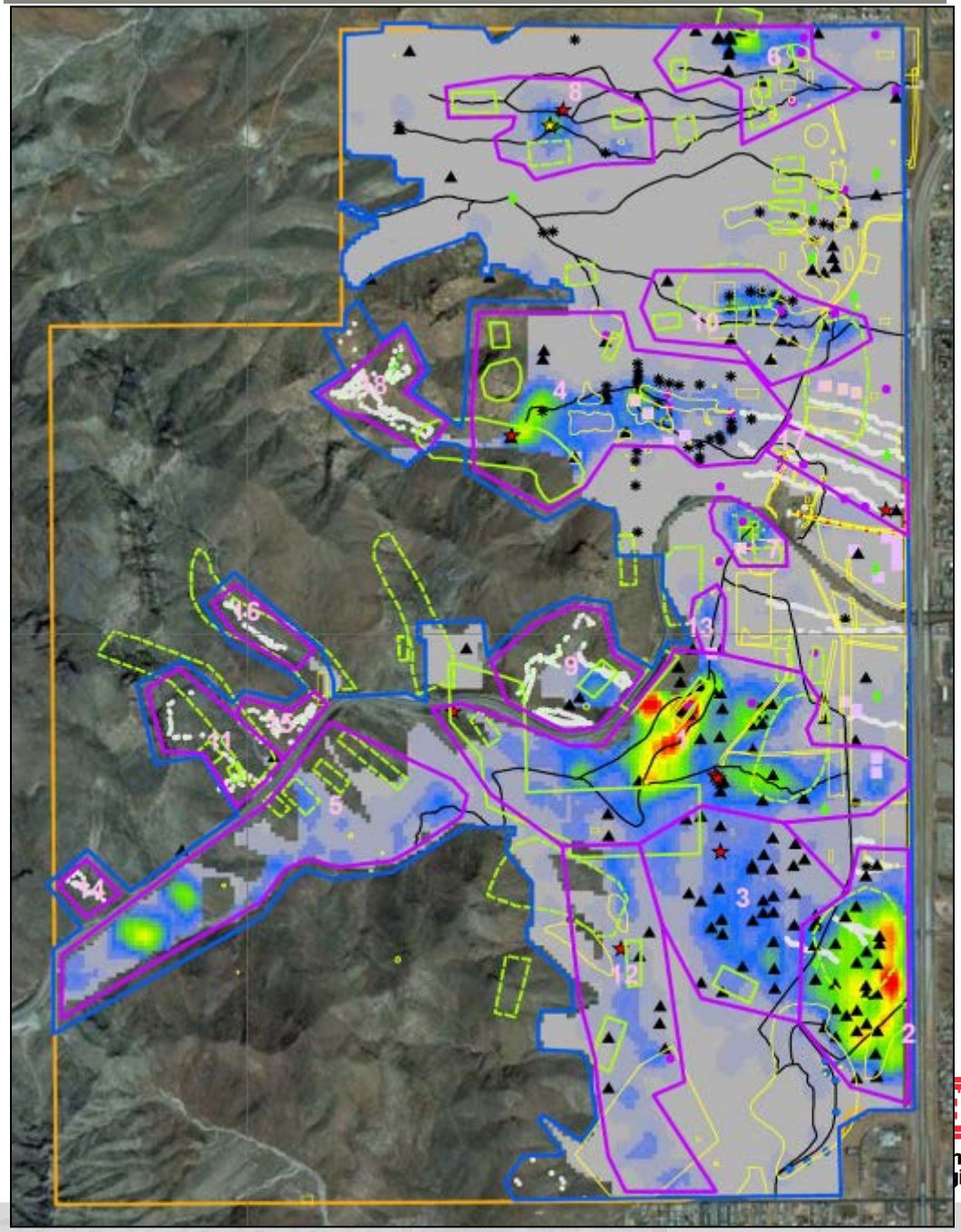
WHERE ARE THE POTENTIAL PROBLEM AREAS?



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Castner Range PDT-Proposed Areas of Interest

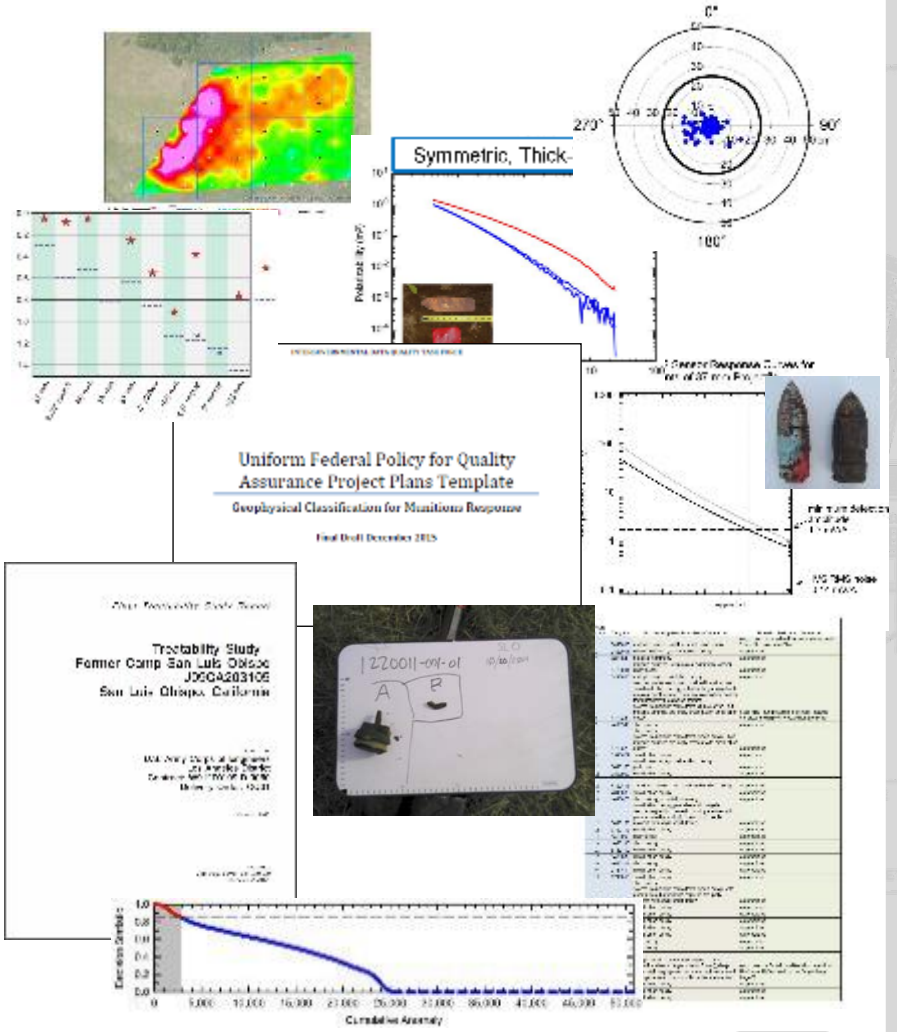


QUIZ TIME!

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QUIZ #1. WHAT DO I NEED AT THE END OF THE PROJECT?

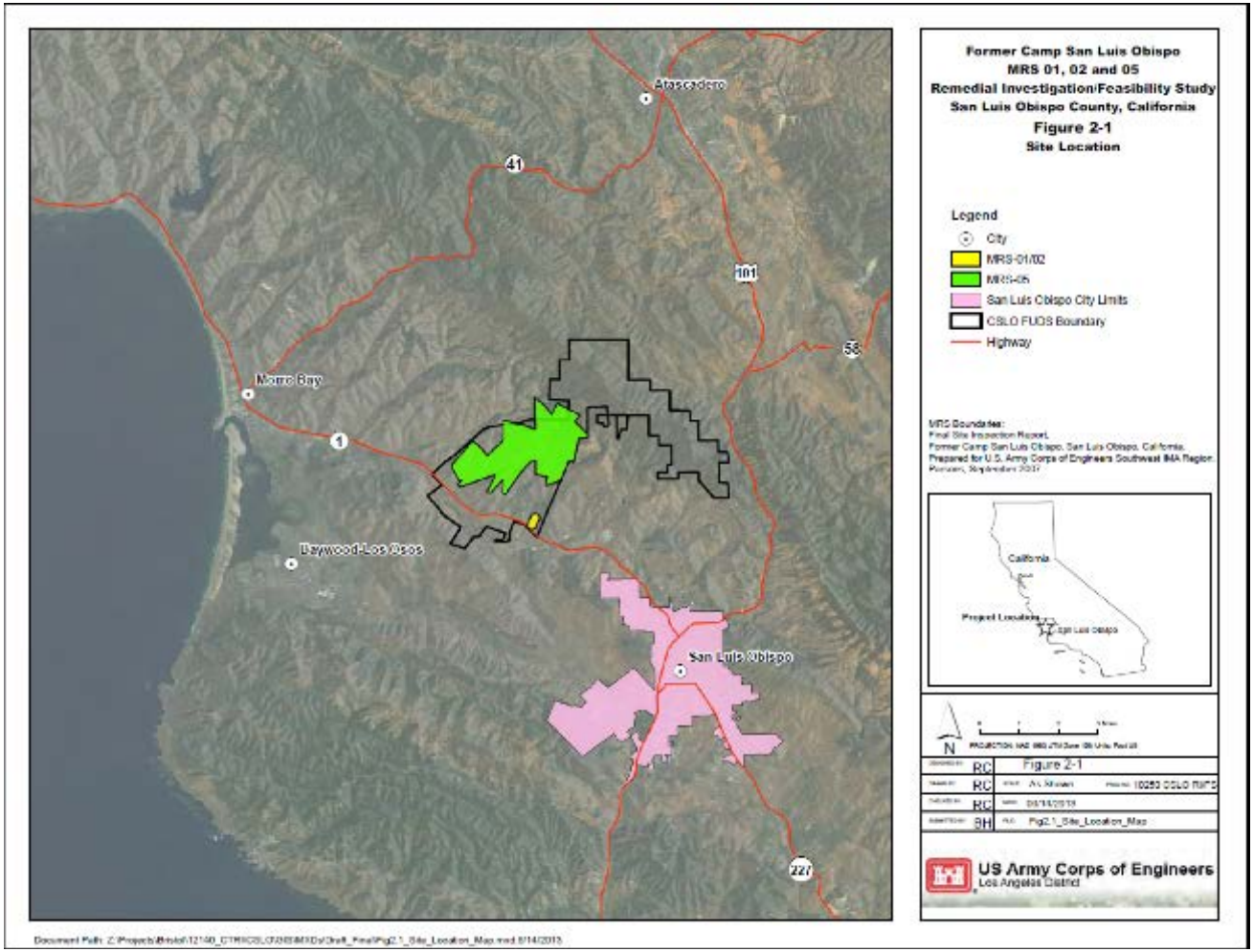
- ✓ QAPP w/ my signature on WS 1&2
- ✓ Draft-Final Report
  - ✓ Source Selection
  - ✓ Classification results
  - ✓ Intrusive Investigations results
  - ✓ Quality Control
    - ✓ QC & QA Seed results
    - ✓ Coverage
    - ✓ Function tests
  - ✓ Data Usability Assessment
    - ✓ Verification dig results
    - ✓ Validation dig results
    - ✓ Summary of any plan deviations
  - ✓ Map showing UXO & TOI locations
  - ✓ Map showing anomaly densities
  - ✓ Vertical CSM
  - ✓ Technical Memoranda



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QUIZ #2. FORMER CAMP SAN LUIS OBISPO - 7ACRES REMEDIAL RESPONSE

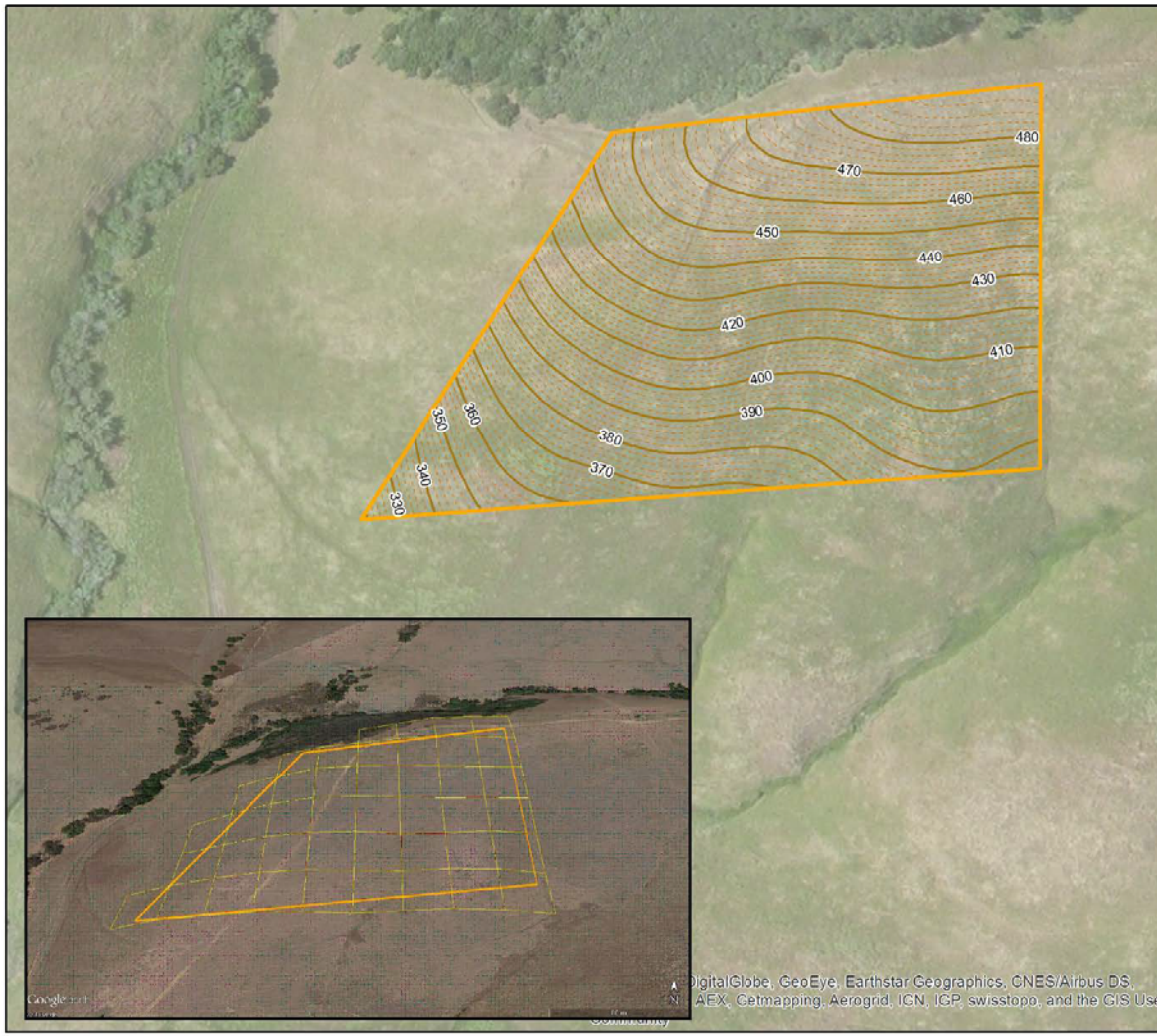


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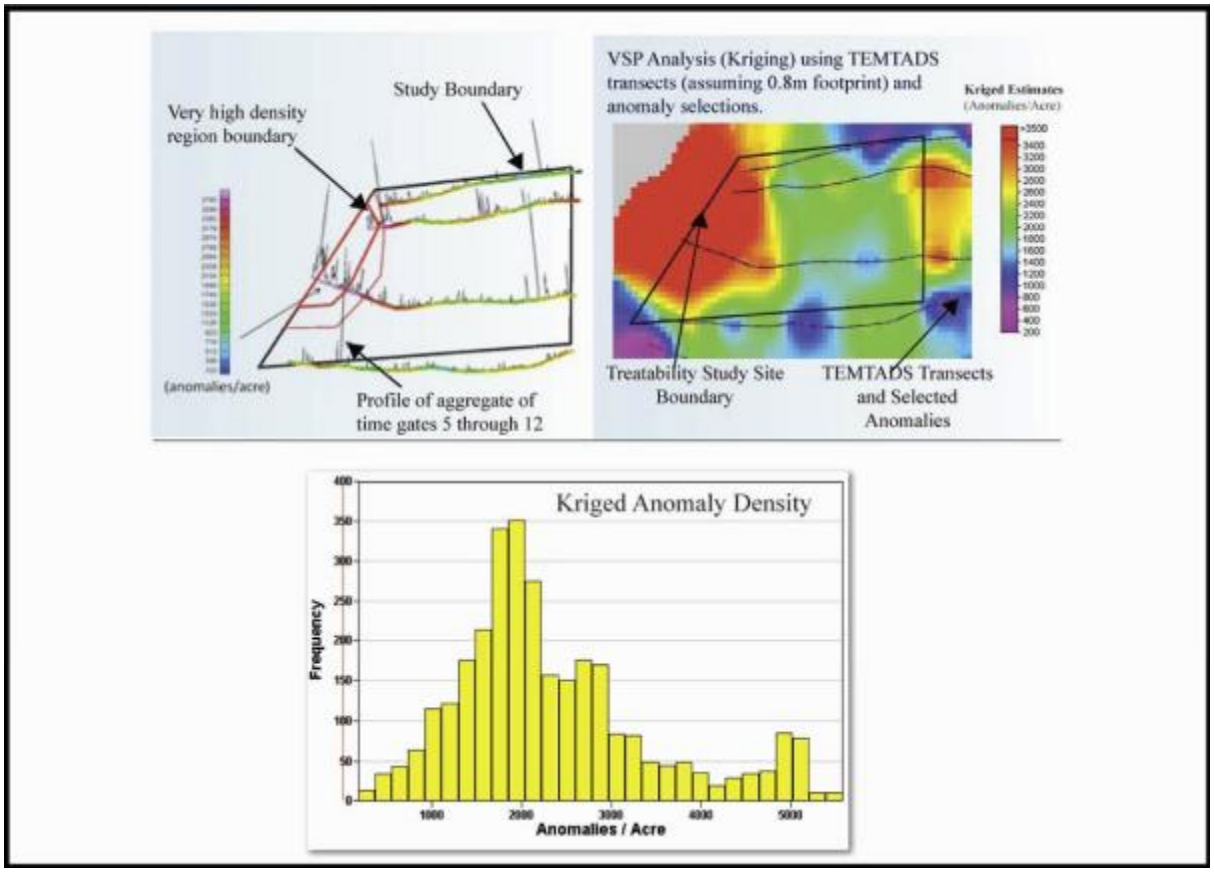
QUIZ #2. FORMER CAMP SAN LUIS OBISPO - 7ACRES LOCATION MAP

LAND USE: Education & Cattle Grazing



QUIZ #2. FORMER CAMP SAN LUIS OBISPO - 7ACRES SCOPING INFORMATION

LAND USE: Education & Cattle Grazing



- Anticipate14,000 Anomalies
- Estimate $1.4M w/ AGC
- Estimate $3M w/out AGC

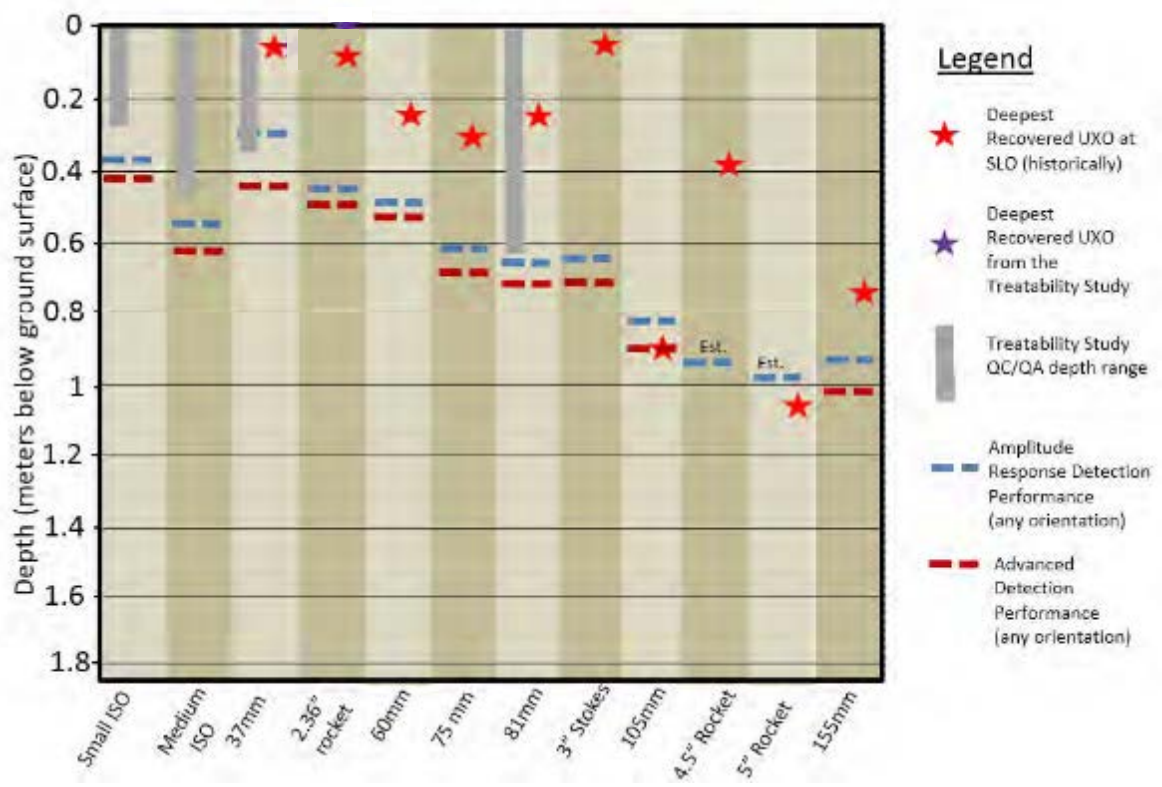
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QUIZ #2. FORMER CAMP SAN LUIS OBISPO - 7ACRES …MORE SCOPING INFORMATION

Remedial Investigation

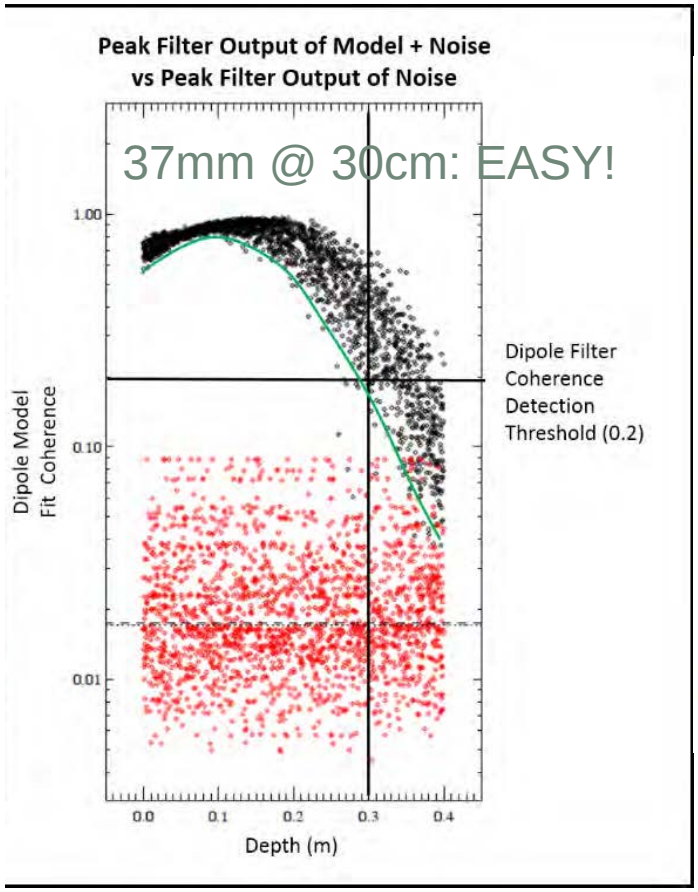
Site-wide Vertical CSM



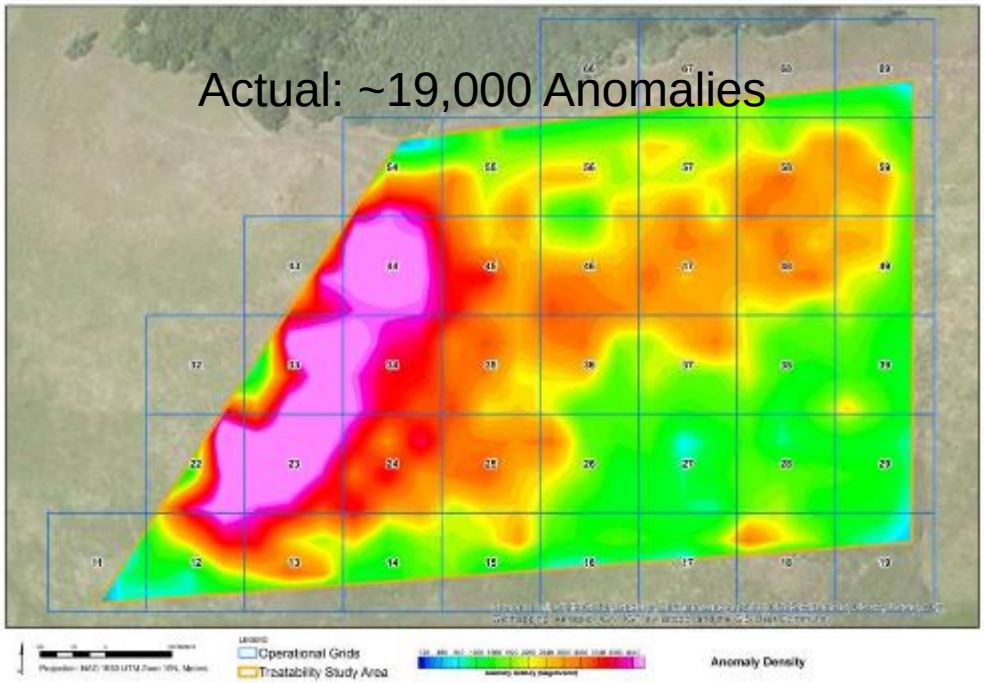
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QUIZ #2. FORMER CAMP SAN LUIS OBISPO - 7ACRES REMEDIAL RESPONSE RESULTS



LAND USE: Education & Cattle Grazing



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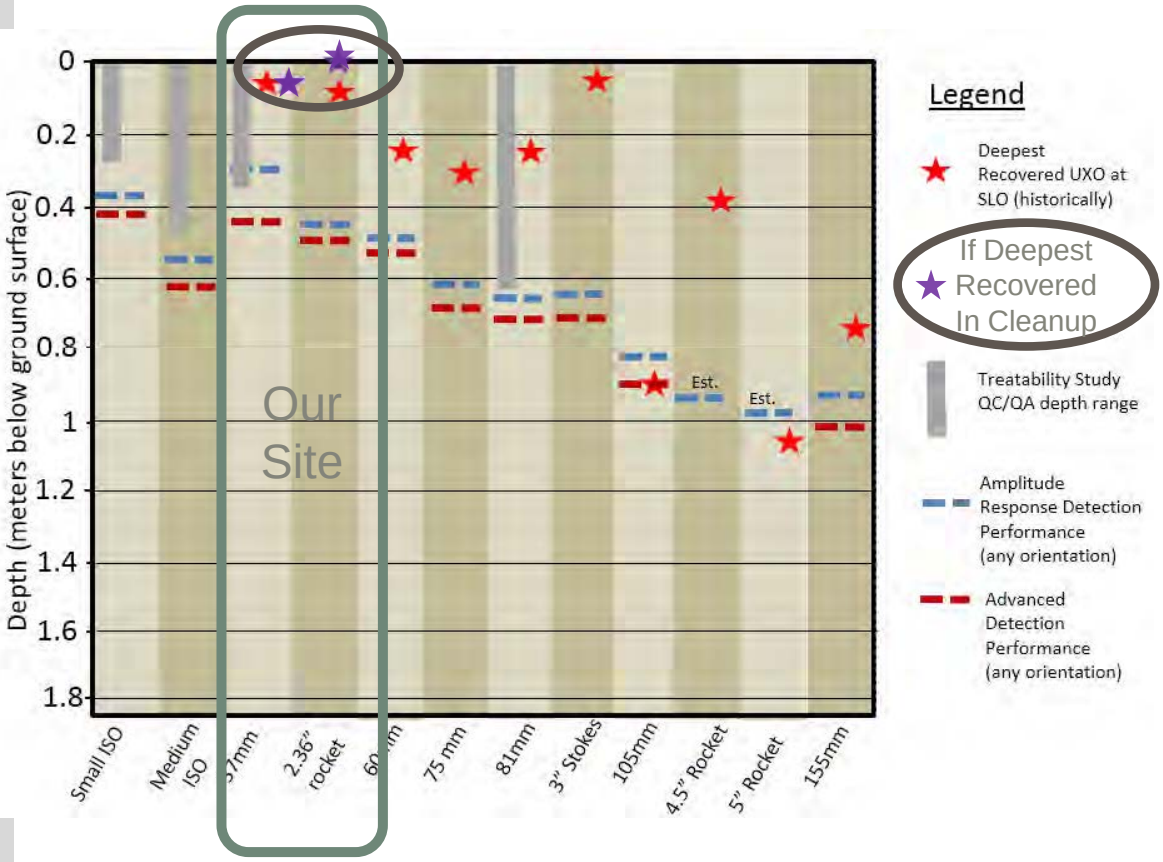
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QUIZ #2. FORMER CAMP SAN LUIS OBISPO - 7ACRES REMEDIAL RESPONSE RESULTS

- ☐ Delineation
- ☐ UU/UE
- ☐ Deed Restriction
- ☐ Construction Support
- ☐ Signage or Education
- ☐ Other LUC

?

LAND USE: Education & Cattle Grazing



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QUIZ #3. FORMER CAMP WHEELER

TCRA Results

- ☐ Delineation
- ☐ U /UE
- ☐ Deed R sti
- ☐ Cons uctio
- ☐ Signage or
- ☐ Other LUC

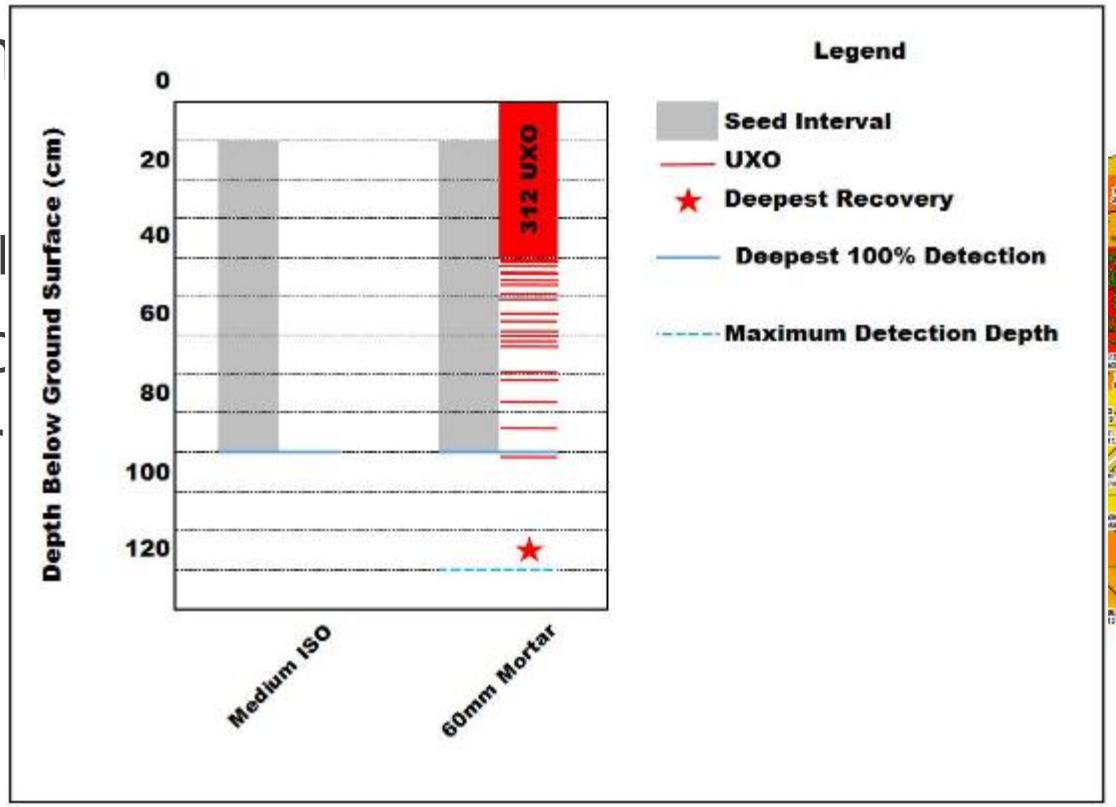
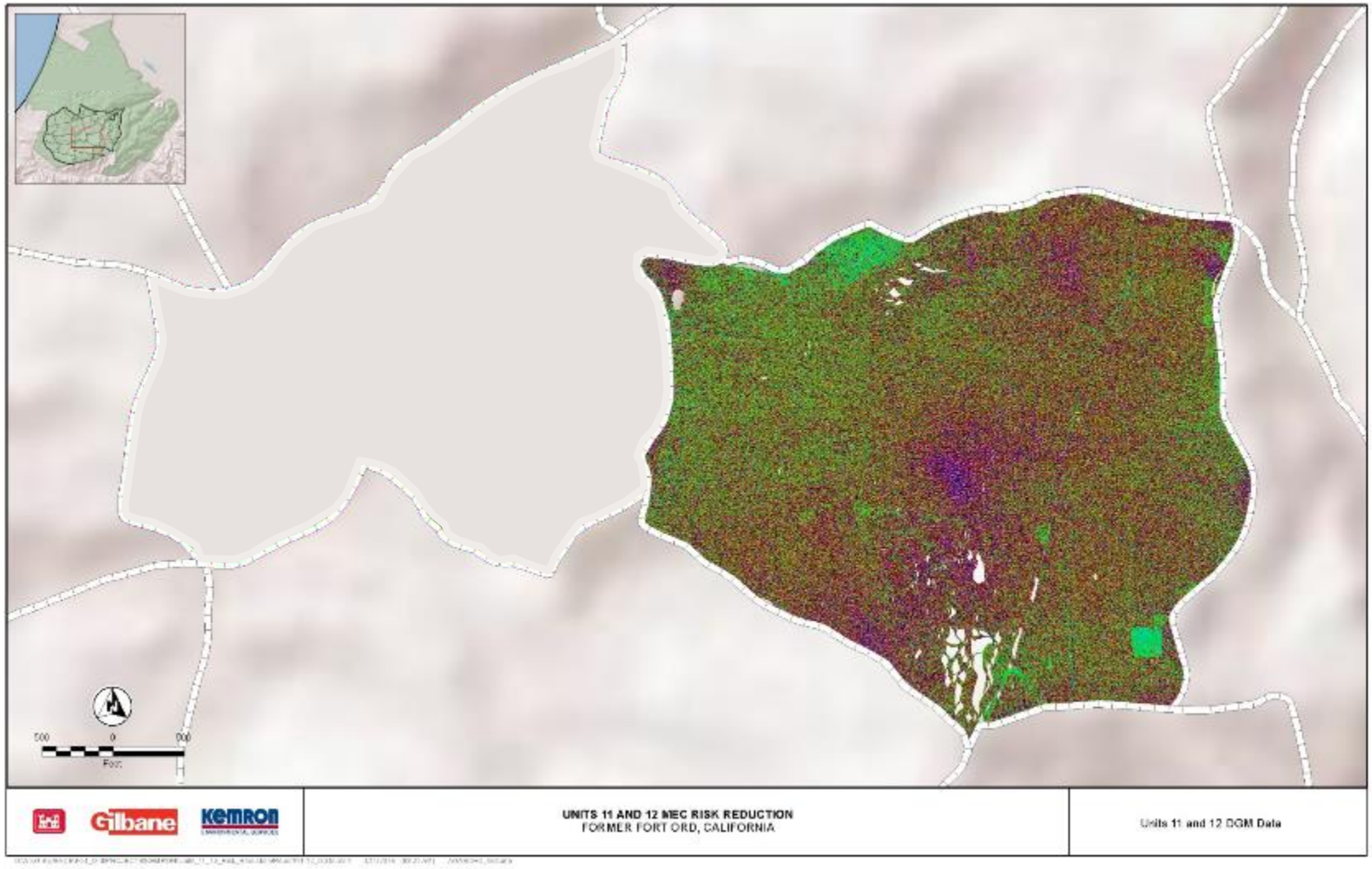


Figure B-11: Former Camp Wheeler - Anomaly Per Acre Concentration Map

QUIZ #4. FORT ORD

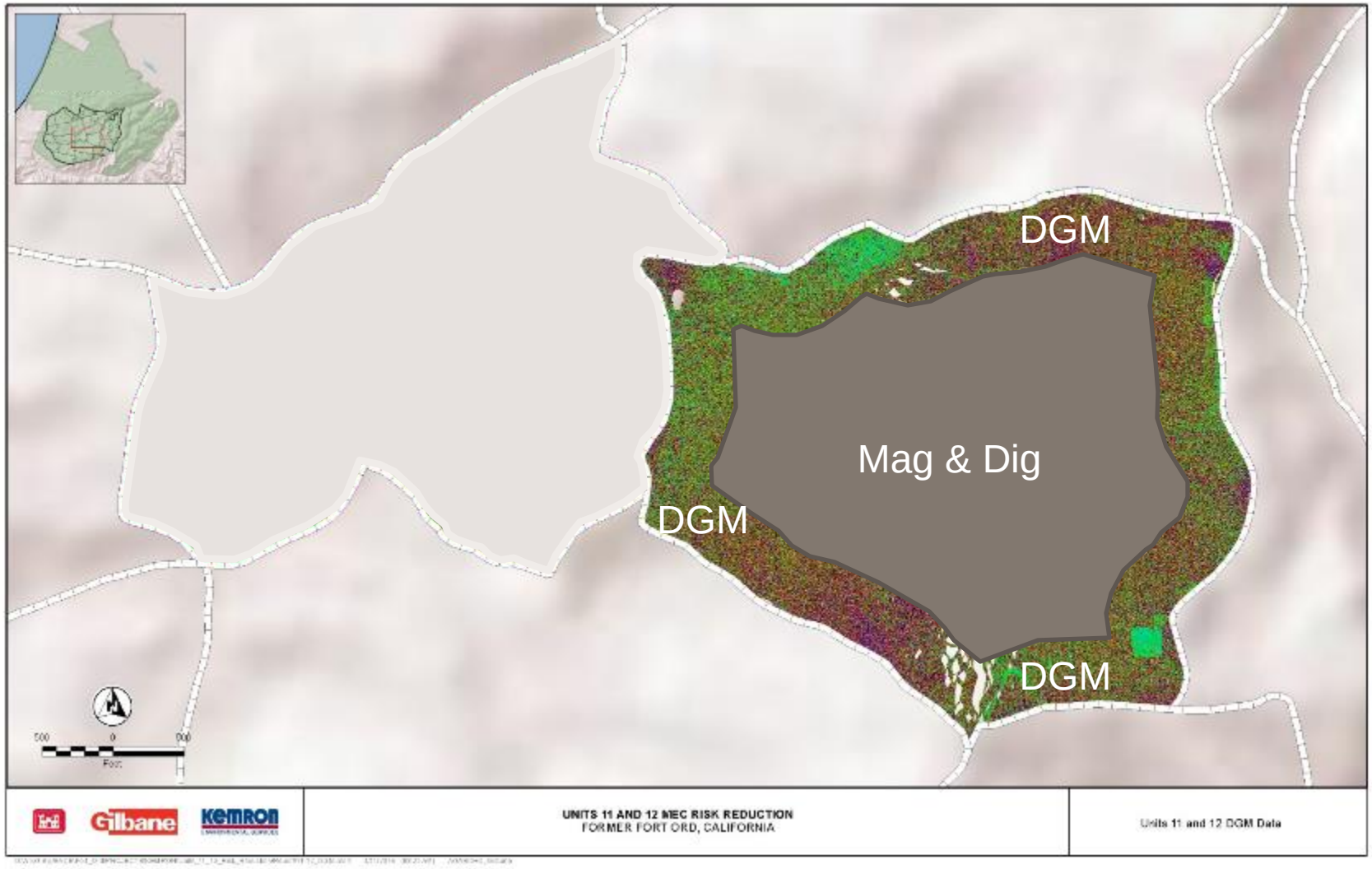
"California Characterization"



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QUIZ #4. FORT ORD

If This Is The Plan

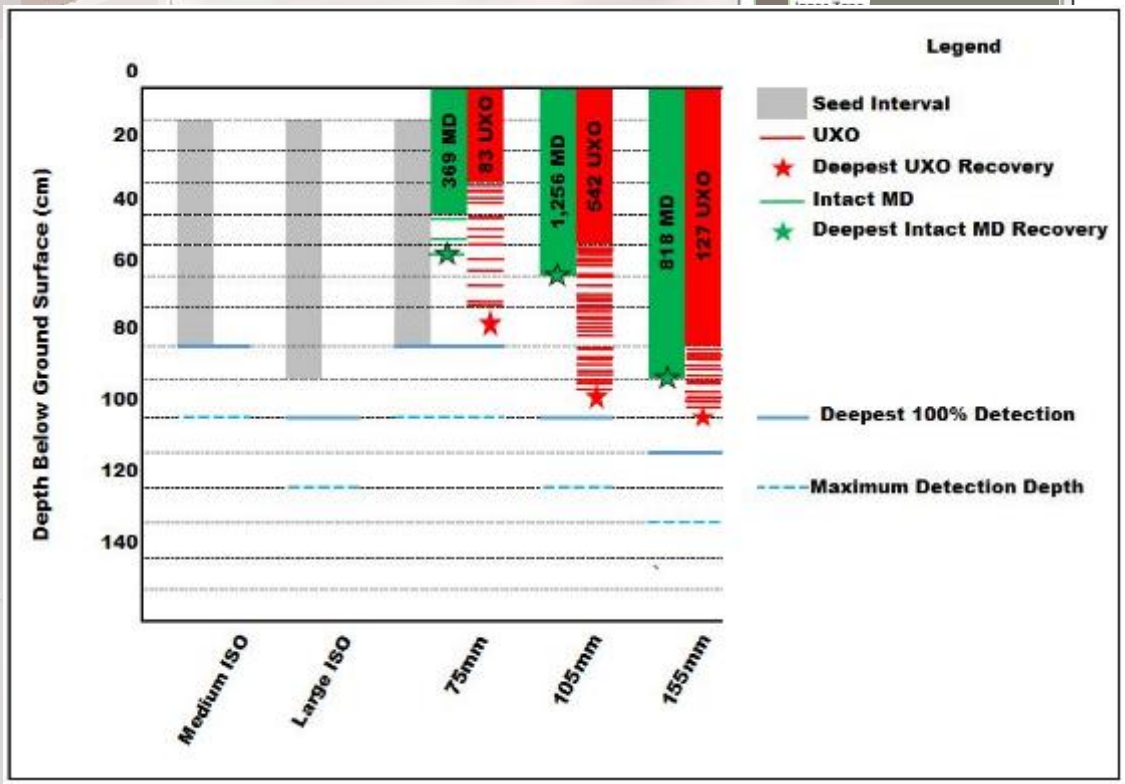


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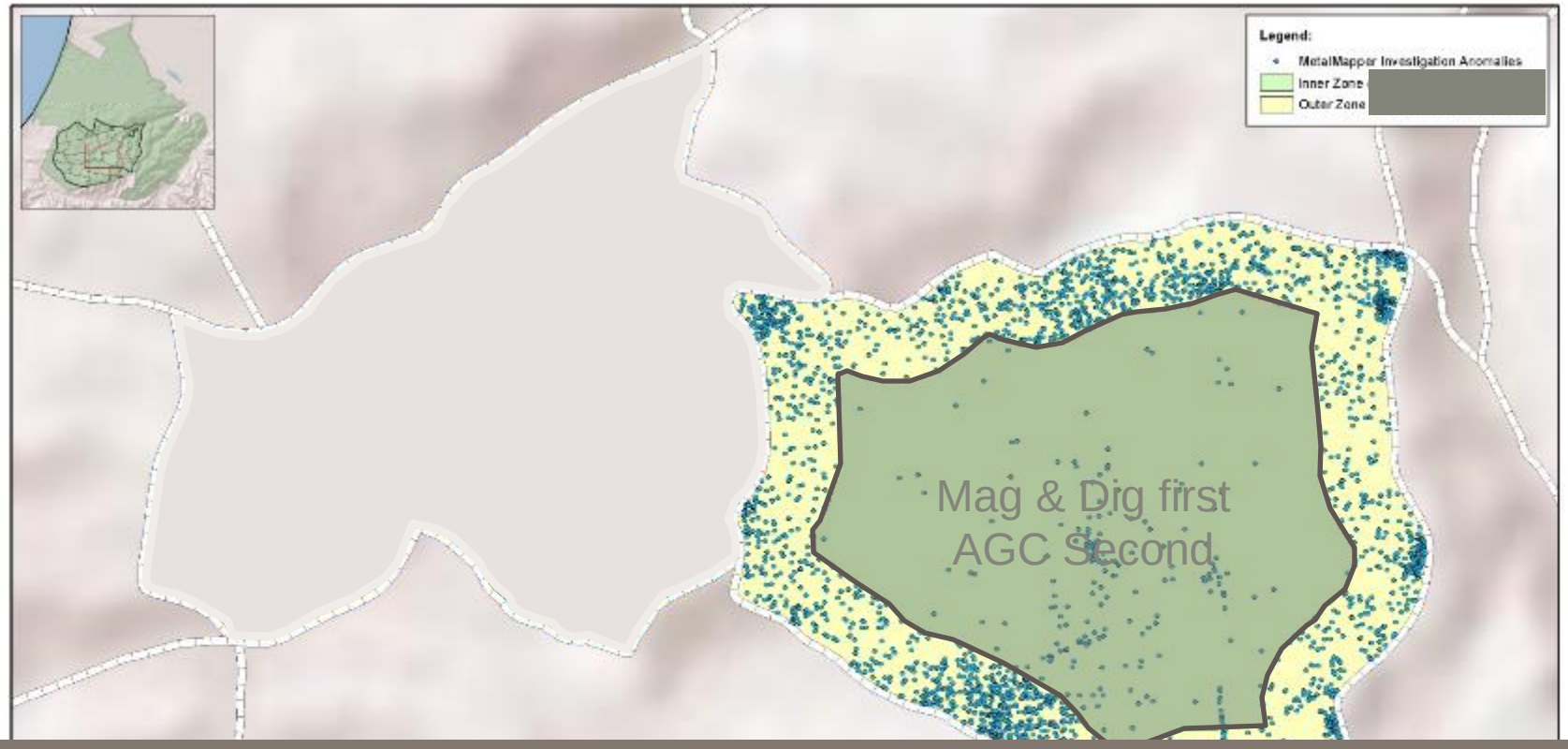
QUIZ #5. FORT ORD

If This Is The Plan & What We Find

- ☐ Delineation
- ☐ UU/UE
- ☐ Deed Restriction
- ☐ Construction Support
- ☐ Signage or Education
- ☐ Other LUC



PEOPLE WILL LIKE, AND COME TO EXPECT HIGH CONFIDENCE DECISIONS



Suggested Path Forward: Surface clearance & vegetation removal tasks become Site Preparation task: Clear the surface of all MEC, reduce vegetation to meet AGC needs, and reduce anomaly densities to less than 3,500/acre.

RECOMMENDATIONS FOR MMRP FS, PP, & DD

Consideration of LUCs

If RAO can be achieved via physical removal, no LUCs necessary.

If physical removal CSM = RI CSM, remedy is achieved.

If physical removal CSM ≠ RI CSM, and RAO not achieved, ESD may be required if LUCs achieve RAO.

Consideration of UU/UE

Separate from assessment of RAO Achievement.

5 YrR required if remedy implemented that does not achieve UU/UE

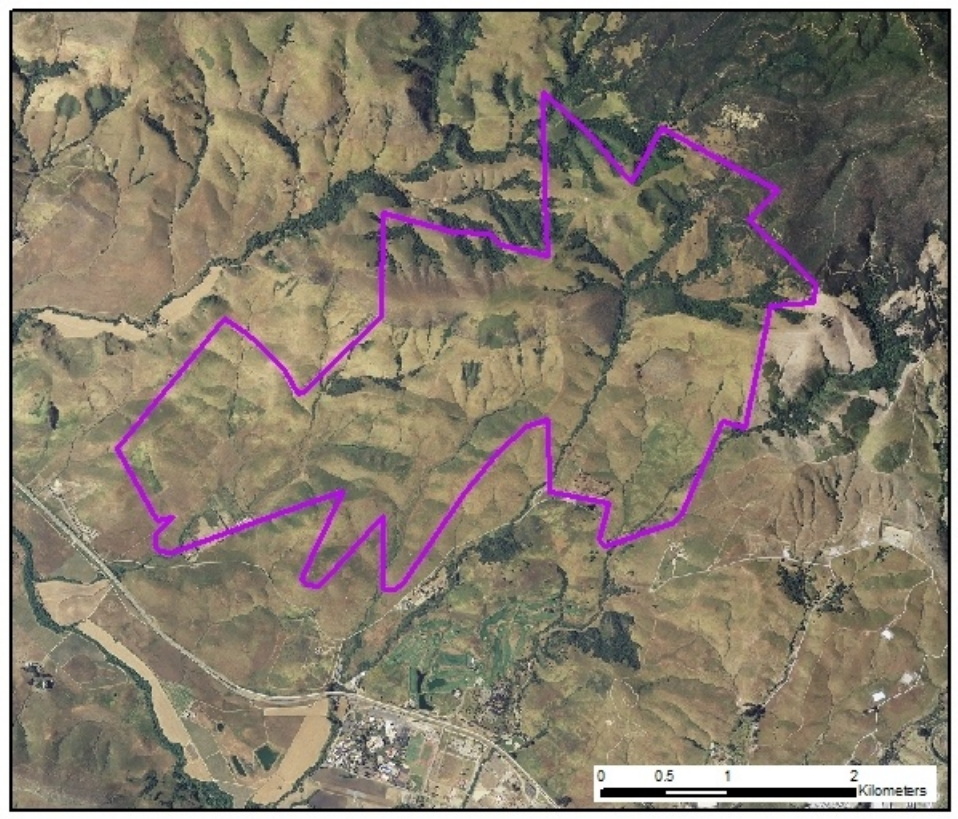
Document in DD

Based on comparing pre-clean-up CSM to post-clean-up CSM

BOOM… WE'RE DONE

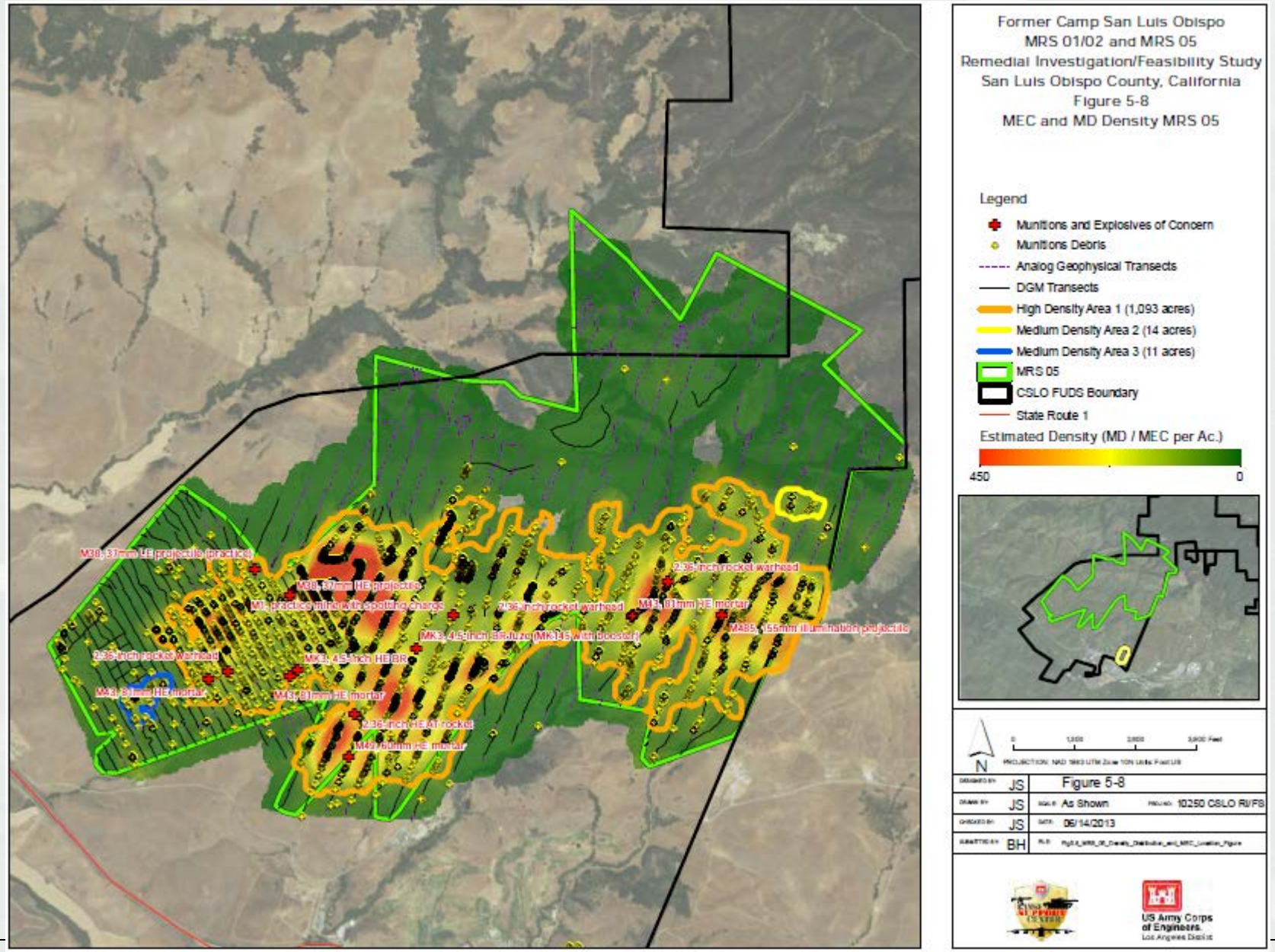
Group Exercise!!!

Remember Camp SLO?



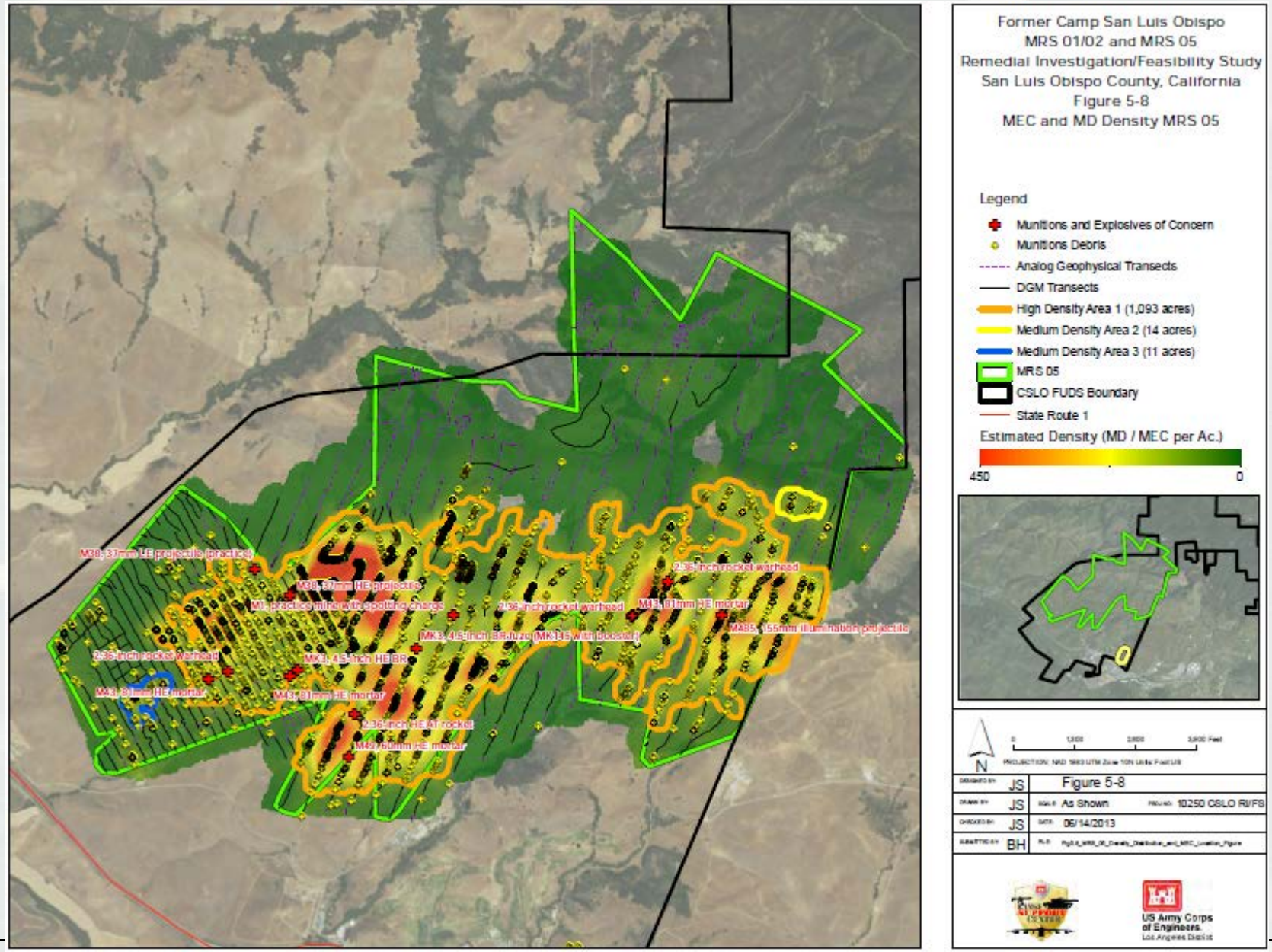
- University owned
  - ► No access restrictions
  - ► Cattle grazing
  - ► Geotechnical classes
  - ► Camping
- Multiple, overlapping range fans
- MRS ~ 2,500 acres

Former Camp SLO RI Results



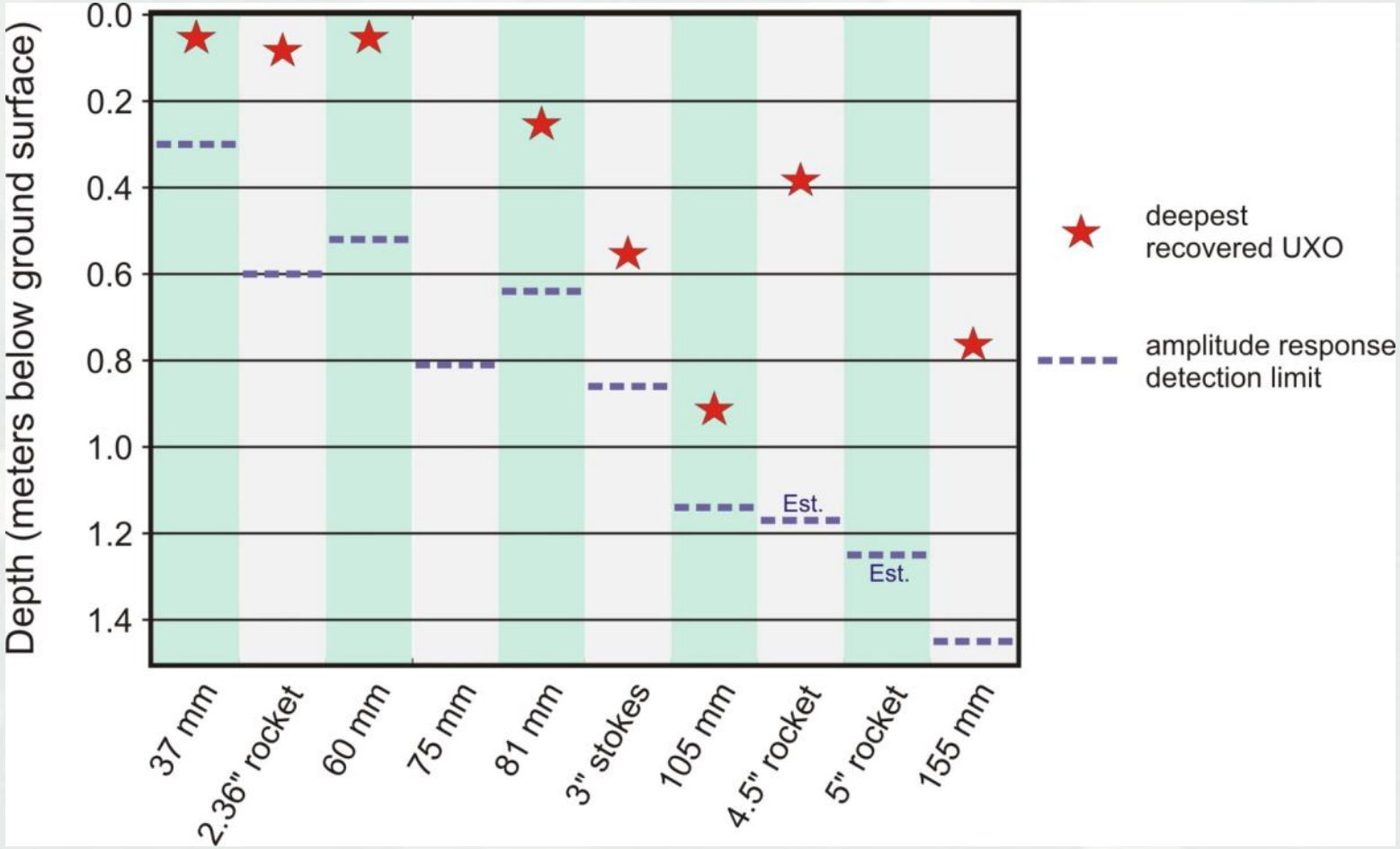
BUILDING STRONG®

Step 1- Delineate the site



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Step 2- Develop RAOs for each (sub)MRS



Step 3- Pick one MRS, create your DQO

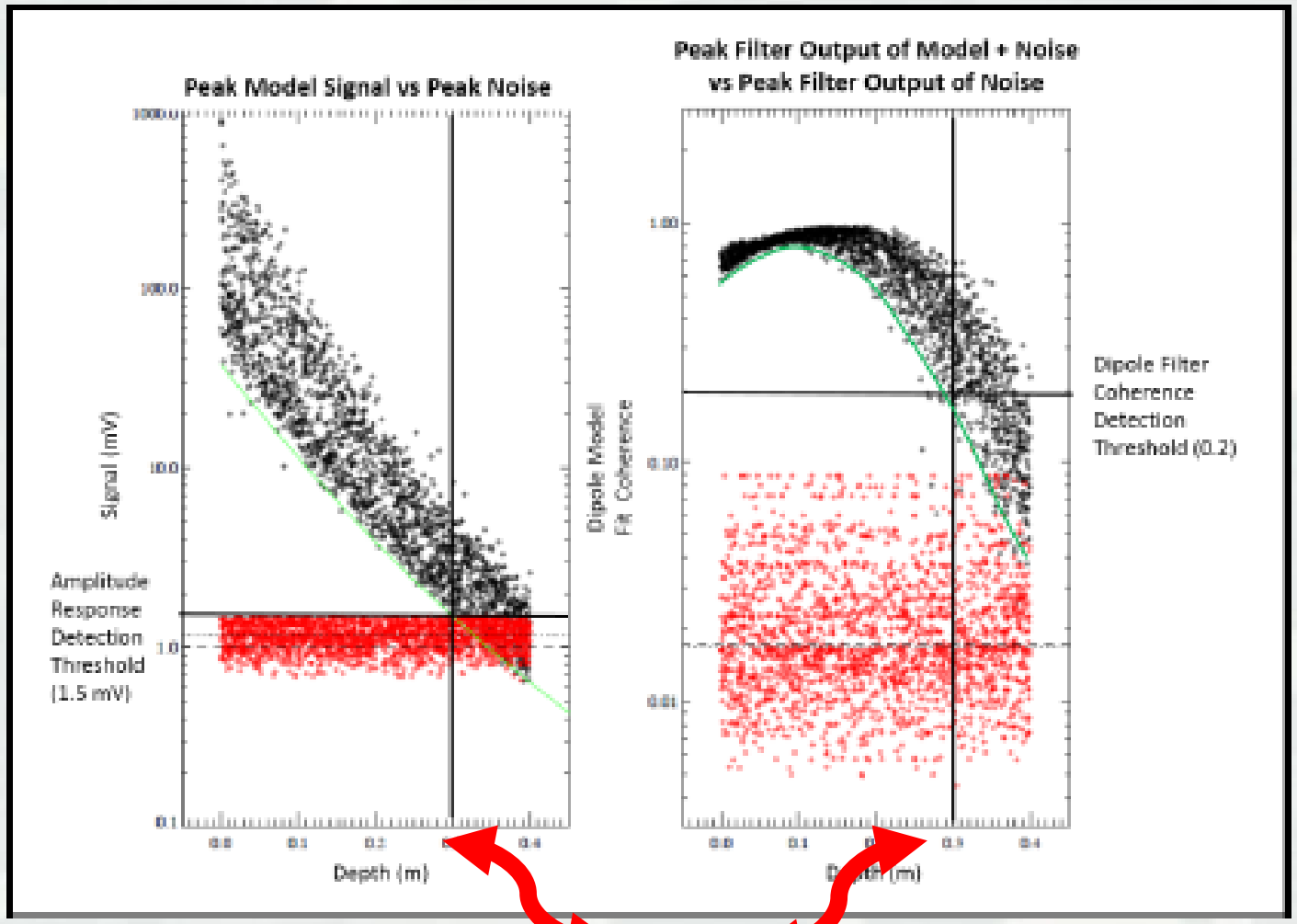
7-step Process

- Step 1: Problem Statement
- Step 2: Goals of the Study
- Step 3: Information Inputs
- Step 4: Boundaries
- Step 5: Analytic Approach
- Step 6: Performance Objectives
- Step 7: Detailed Plan to Obtain Data

Instructions

- Write a detailed problem statement
- Provide general statements or ideas for the other 6 steps

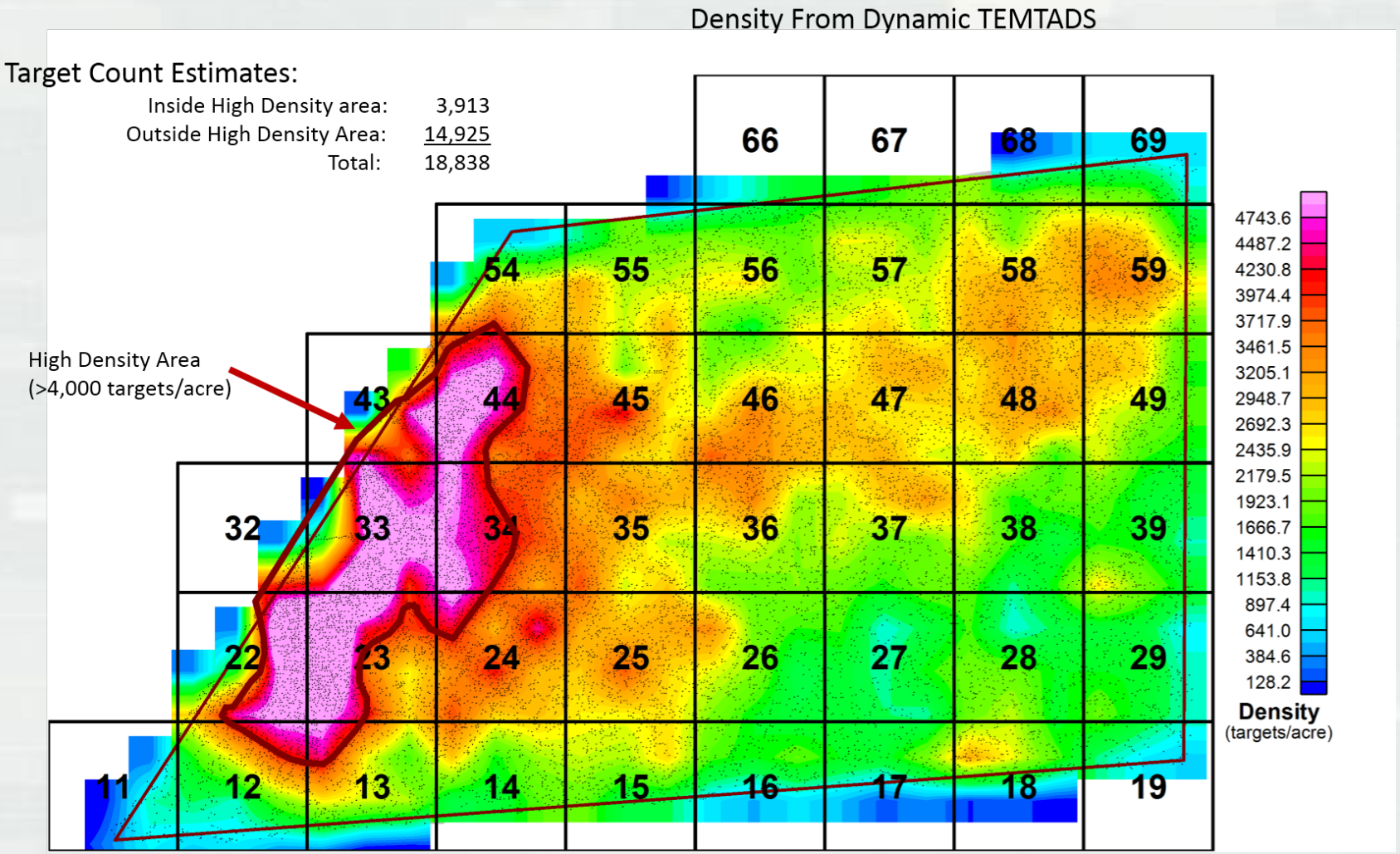
Post Remedy- Scenario 1



1 foot

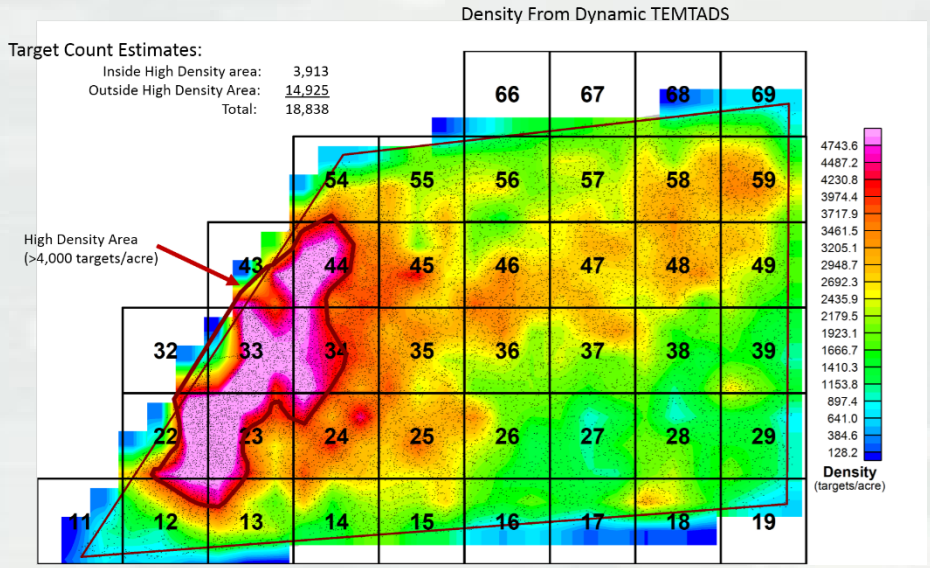
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Scenario 1- High density not completed- data gap



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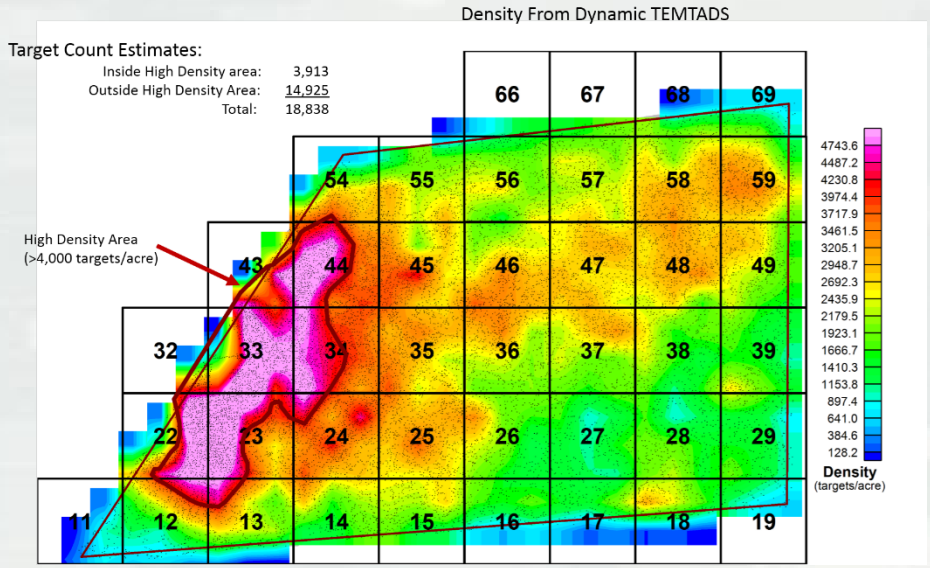
Scenario 1- High density not completed- data gap



Questions

- Did we meet the RAO and intent of the ROD?
- ROD requires explanation of significant differenced?
  - What would the ESD look like?
- LUCs?
  - How do we implement on state lands?
  - How do we implement on private lands?

Scenario 2- High density completed- NO data gap



Questions

- Did we meet the RAO and intent of the ROD?
- ROD requires explanation of significant differenced?
  - What would the ESD look like?
- LUCs?
  - How do we implement on state lands?
  - How do we implement on private lands?

Scenario 3- Dig results comparison

3a

Anomaly/Target Quantities Amplitude Response Anomalies Detected	16,202
Advanced Detection Analysis Targets (Potential TOI Identified for Cued Analysis)	7,035
Targets Identified for Dig List	753
Can't Analyze	(104)
Potential TOI	(418)
Calibration, Threshold Verification and Validation Digs	(231)
Dig Records in Database (more than one item found within a 0.4 meter radius resulted in multiple records for an investigated location)	1,456
Munitions Debris (note that some of the individual records indicate multiple pieces of frag)	(1,223)
QC or QA Seed	(94)
Other Debris (Primarily Scrap Metal)	(62)
Small Arms	(36)
No Contact	(36)
Other (shared with adjacent anomaly)	(4)
UXO	(1)

3b

Anomaly/Target Quantities Amplitude Response Anomalies Detected	16,202
Advanced Detection Analysis Targets (Potential TOI Identified for Cued Analysis)	7,035
Targets Identified for Dig List	753
Can't Analyze	(104)
Potential TOI	(418)
Calibration, Threshold Verification and Validation Digs	(231)
Dig Records in Database (more than one item found within a 0.4 meter radius resulted in multiple records for an investigated location)	1,456
Munitions Debris (note that some of the individual records indicate multiple pieces of frag)	(1,223)
QC or QA Seed	(94)
Other Debris (Primarily Scrap Metal)	(62)
Small Arms	(36)
No Contact	(36)
Other (shared with adjacent anomaly)	(4)
UXO	(38)

Scenario 4- verification/validation

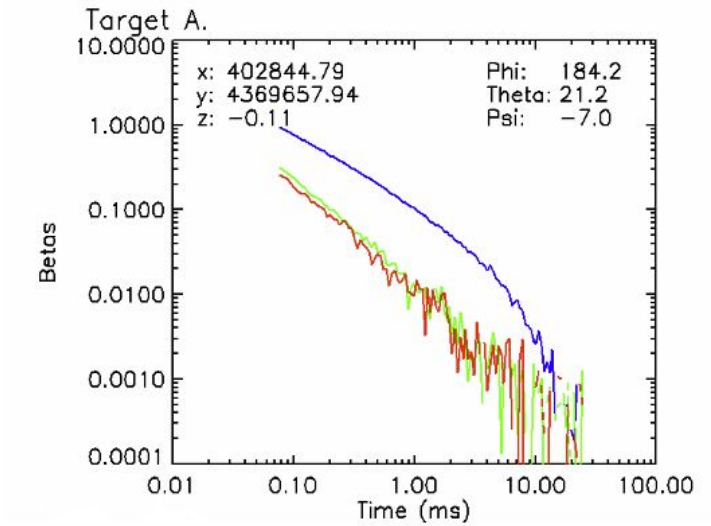
4a

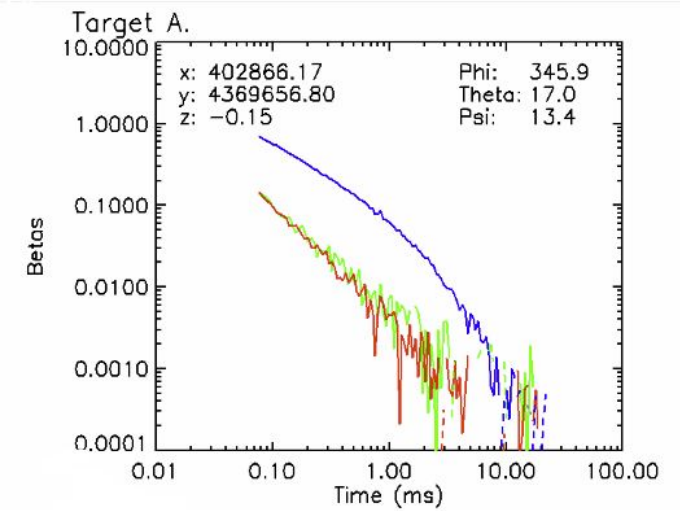
Anomaly/Target Quantities Amplitude Response Anomalies Detected	16,202
Advanced Detection Analysis Targets (Potential TOI Identified for Cued Analysis)	7,035
Targets Identified for Dig List	553
Can't Analyze	(104)
Potential TOI	(418)
Calibration, Threshold Verification and Validation Digs	(31)
Dig Records in Database (more than one item found within a 0.4 meter radius resulted in multiple records for an investigated location)	1,456
Munitions Debris (note that some of the individual records indicate multiple pieces of frag)	(1,223)
QC or QA Seed	(14)
Other Debris (Primarily Scrap Metal)	(62)
Small Arms	(36)
No Contact	(36)
Other (shared with adjacent anomaly)	(4)
UXO	(1)

4b

Anomaly/Target Quantities Amplitude Response Anomalies Detected	16,202
Advanced Detection Analysis Targets (Potential TOI Identified for Cued Analysis)	7,035
Targets Identified for Dig List	2753
Can't Analyze	(2104)
Potential TOI	(418)
Calibration, Threshold Verification and Validation Digs	(231)
Dig Records in Database (more than one item found within a 0.4 meter radius resulted in multiple records for an investigated location)	1,456
Munitions Debris (note that some of the individual records indicate multiple pieces of frag)	(1,223)
QC or QA Seed	(94)
Other Debris (Primarily Scrap Metal)	(62)
Small Arms	(36)
No Contact	(36)
Other (shared with adjacent anomaly)	(4)
UXO	(38)

Sorry about the scales!





Size





A is _____ B

- o Larger Than
- o Smaller Than
- The Same Size as

Size



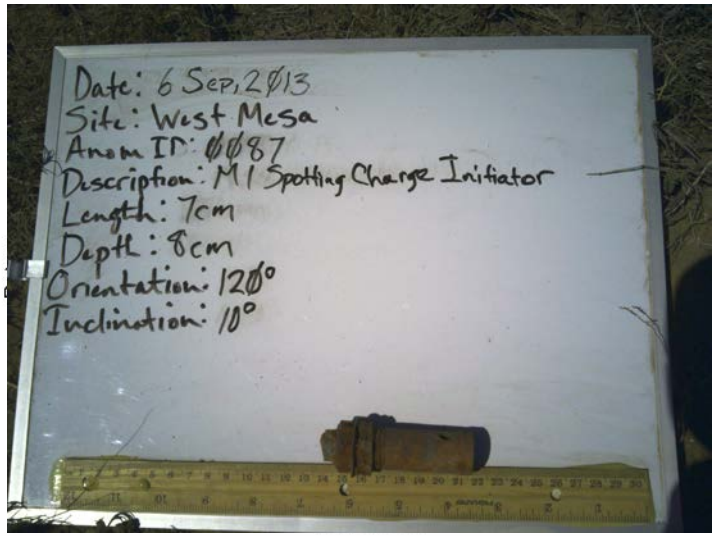


A is _____ B

- Larger Than
- Smaller Than
- The Same Size as

Size





A is _____ B

- Larger Than
- Smaller Than
- The Same Size as

Size





A is _____ B

- Larger Than
- Smaller Than
- The Same Size as

Wall Thickness





A has _____ wall thickness than/as B

- A Thinner
- A Thicker
- The Same

Wall Thickness





A has _____ wall thickness than/as B

- A Thinner
- A Thicker
- The Same

Wall Thickness





A has _____ wall thickness than/as B

- o A Thinner
- o A Thicker
- ● The Same

Wall Thickness





A has _____ wall thickness as B

- A Thinner
- A Thicker
- The Same

Symmetry



This source is

- Axially symmetric
  - Cubic or Spherical
  - Rectangular
  - None of the above

Symmetry



This source is

- Axially symmetric
- Cubic or Spherical
- Rectangular
- None of the above

Symmetry



This source is

- Axially symmetric
- Cubic or Spherical
- Rectangular
- None of the above

Symmetry



This source is

- Axially symmetric
- Cubic or Spherical
- Rectangular
- None of the above

Symmetry



This source is

- Axially symmetric
- Cubic or Spherical
- Rectangular
- None of the above

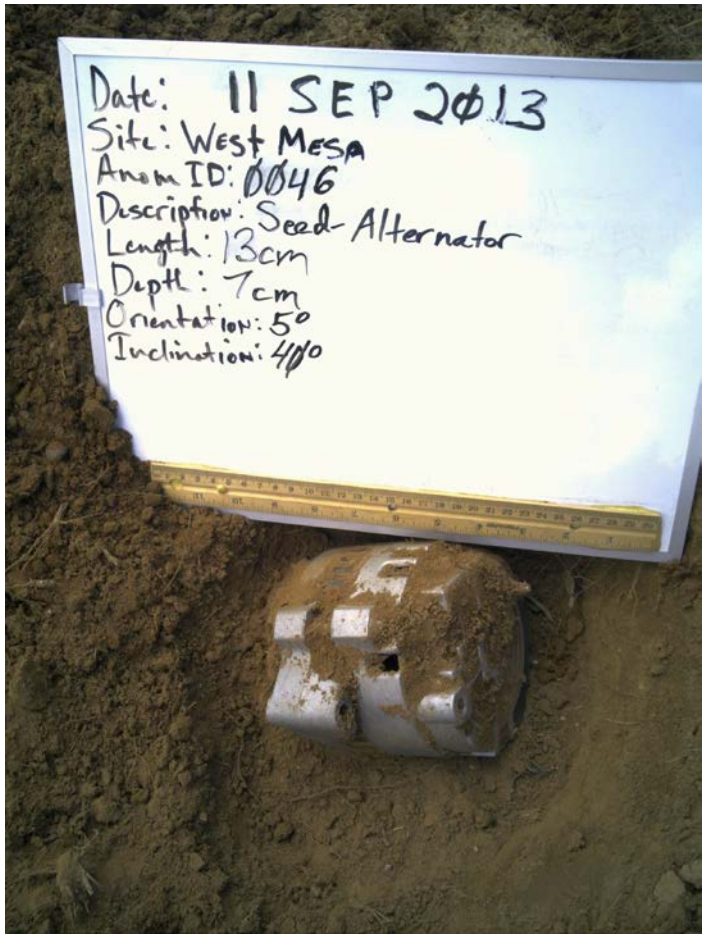
Symmetry



This source is

- Axially symmetric
- Cubic or Spherical
- Rectangular
- None of the above

Symmetry



This source is

- Axially symmetric
- Cubic or Spherical
- Rectangular
- None of the above

True or False



True or False

This source is…

Large	True
Axially symmetric	True
Thick walled	False
Is probably a UXO	False

True or False

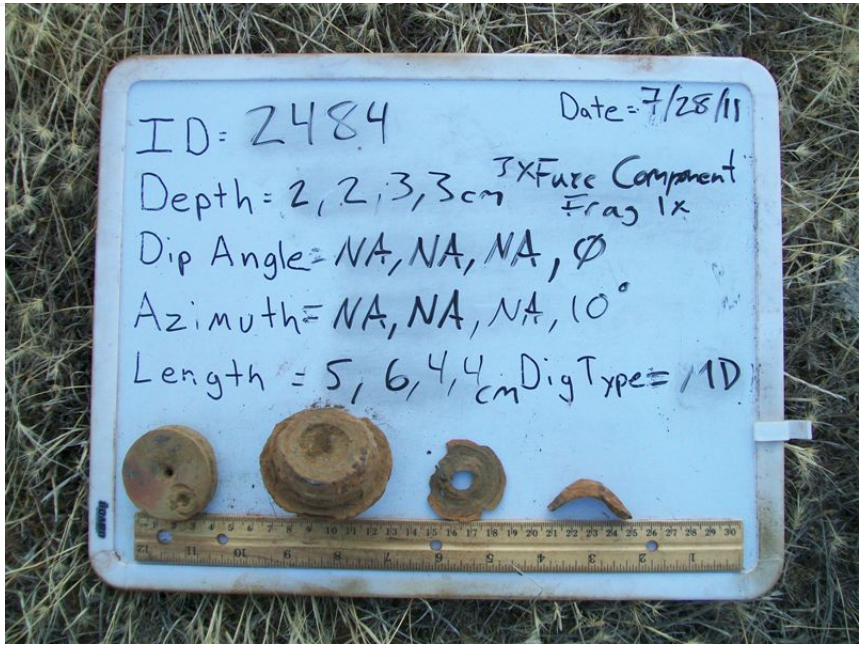


True or False

This source is…

Large	True
Axially symmetric	True
Thick walled	True
Is probably a UXO	True

True or False



True or False

This source is…

Large	True
Axially symmetric	False
Thick walled	True
Is probably a UXO	False

True or False



True or False

This source is…

Large	False
Axially symmetric	False
Thick walled	False
Is probably a UXO	False

True or False



True or False

This source is…

Large	True
Axially symmetric	True
Thick walled	Maybe?
Is probably a UXO	Maybe?

True or False

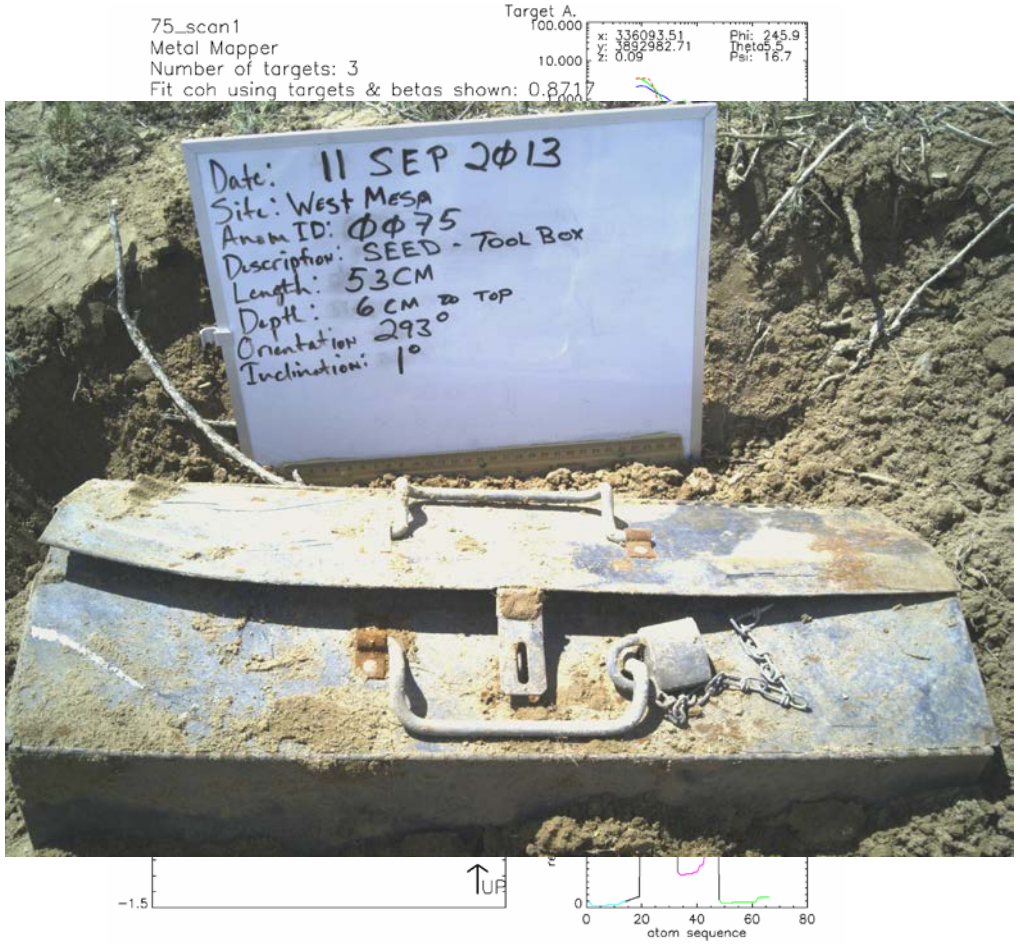


True or False

This source is…

Large	True
Axially symmetric	True
Thick walled	True
Is probably a UXO	True

True or False



True or False

This source is…

Large	True
Axially symmetric	False
Thick walled	True
Is probably a UXO	False